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HAWAII AGRICULTURAL EXPERIMENT STATION,
J. M. WESTGATE, Agronomist in Charge,
Honolulu, Hawaii.

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION.

1920.

Issued December 16, 1921.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1921.

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[Under the supervision of A. C. TRUE, Director, States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief, Office of Experiment Stations.*
WALTER H. EVANS, *Chief, Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

J. M. WESTGATE, *Agronomist in Charge.*
WILLIS T. POPE, *Horticulturist.*[1]
WALLACE MACFARLANE, *Specialist in Soil Fertility Investigations.*[2]
F. G. KRAUSS, *Superintendent of Extension Work.*
C. W. CARPENTER, *Plant Pathologist.*[3]
H. L. CHUNG, *Agronomist.*
K. A. CHING, *Assistant Chemist.*[4]
J. C. RIPPERTON, *Assistant Chemist.*[5]
R. A. GOFF, *Extension Agent, Island of Hawaii.*

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[1] Appointed July 1, 1920, to succeed J. E. Higgins, resigned, Jan. 22, 1920.
[2] Resigned May 20, 1920.
[3] Resigned Nov. 15, 1919.
[4] Resigned July 10, 1920.
[5] Appointed June 25, 1920.

LETTER OF TRANSMITTAL.

HAWAII AGRICULTURAL EXPERIMENT STATION,
Honolulu, Hawaii, October 19, 1920.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Hawaii Agricultural Experiment Station, 1920.

Respectfully,

J. M. WESTGATE,
Agronomist in Charge.

DR. A. C. TRUE,
Director, States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
HENRY C. WALLACE,
Secretary of Agriculture.

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REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION, 1920.

SUMMARY OF INVESTIGATIONS.

By J. M. WESTGATE, *Agronomist in Charge.*

INTRODUCTION.

The fiscal year 1920 as a whole was one of readjustment from wartime to peace conditions. The more essential wartime activities were continued by the station; those of less importance were suspended in favor of the investigational work that had been dropped on account of urgent war needs. The station continued to foster in every way possible the development of diversified agricultural industries. Special attention was given again to the production and preservation of food products. Emphasis was laid upon this important line of work because the island would be in a precarious condition were shipping interrupted for any length of time. Hawaii is 2,000 miles or more from her nearest neighbor and depends to a large extent upon the outside world for her food supply. It is inevitable that the numerous nationalities making their homes in Hawaii will continue during normal times to import favorite articles of foodstuffs from their native countries. On this account it would seem advisable to plan for the production of foodstuffs that can serve as articles of export during these times and can be diverted to feed the local population during an interruption to shipping. Such a production would bring money in any event to the producers because cessation of shipping would not result in a lack of demand for their products. The excess production of foodstuffs exported should at least equal in food value the normal imports of foodstuffs, so that the two would automatically balance in case imports were cut off.

CHANGES IN THE STATION STAFF.

The work of the station suffered considerably during the year by reason of numerous resignations from the staff. Many of the members found more remunerative positions elsewhere, principally with the large commercial concerns of the islands. C. W. Carpenter, pathologist of the station since June 1, 1916, resigned November 15, 1919, to accept a similar position with the Sugar Planters' Experiment Station, Honolulu. Mr. Carpenter desires to continue work along the lines of initial discoveries in connection with the cause of the Lahaina disease of sugar cane and wilt of pineapples. J. E. Higgins, horticulturist of the station for about 15 years, resigned January 22, 1920, to become professor of agriculture in the College of Agriculture, Los Banos, Philippine Islands. Willis T. Pope, of the University of California, was appointed horticulturist July 1, 1920. In addition to his work as horticulturist, he will attend to the more pressing problems of plant disease and insect-control work. Wallace Macfarlane, specialist in soil fertility investigations, resigned May 20, 1920, to take a position as agricultural adviser with a fertilizer company. K. A. Ching, assistant chemist, resigned July 10, 1920, to become chemist of a packing corporation. He began work with this station on September 16, 1917. J. C. Ripperton was appointed assistant chemist on June 25, 1920.

SUBSTATIONS.

Hawaii is characterized by numerous variations in its soil, climate, winds, altitude, and rainfall. The altitudes at which agricultural operations are carried on vary from sea level to 5,000 feet; the rainfall varies from less than 10 inches a year in some sections to 600 inches a year near the top of the wettest mountain. In Hawaii it is manifestly impossible to locate an experiment station so that it will be typical of the many conditions existing in the various sections. On account of this difficulty it was necessary to establish substations in the more important agricultural sections, so that results might have a direct bearing in indicating the best agricultural practice for the particular section in question.

It has been deemed important to have at hand definite experimental data regarding the new homestead tracts that are being opened up for settlement. A new substation has recently been established at the Haleakala homesteads on the island of Maui in cooperation with the Territorial government, which has just finished the erection of a set of farm buildings there. The farm will be made as far as possible self supporting. The experimental tracts are relatively small compared with the demonstration tracts, and the latter can be operated at a profit nearly sufficient to offset the expense of the former. The products from the experimental tract generally fail to meet the cost of its upkeep. The station furnishes the plans of all work and pays for the extra work entailed by the operation of the experimental plats. A similar plan was put in operation at the Glenwood demonstration farm on the island of Hawaii, when the Territorial legislature withdrew its financial support on June 30, 1919. The work at the Tantalus substation was continued during the year. This substation is located on the upper end of the reservation occupied by the central station adjoining Honolulu. It is about 1,000 feet higher than the central station and offers conditions that differ from those at the lower elevation. The work at the Castner substation was suspended in July, 1919, so far as active financial support on the part of the central station was concerned. Lack of sufficient appropriations to maintain all the customary projects and substations made this necessary. The foreman was taken over by the Army for work similar to that done by him at the station. He continued to occupy the foreman's quarters at the substation, however, and between times was able to carry on work with the more important permanent plats of grasses and forage crops.

It was found practicable to continue cooperative relations with a number of small growers as well as with the larger concerns interested in agricultural operations. They have benefited by the experiments conducted on their own lands; and the station in turn has been able to utilize the results obtained without having to pay for the care of the fields and the cultivation and harvesting of the crops. In this way a great deal of valuable agricultural information was gleaned at a nominal outlay on the part of the station.

COOPERATION WITH MILITARY POSTS.

During the year the numerous military posts located on the island of Oahu depended considerably upon the station for suggestions regarding the best method of utilizing the grounds surrounding their quarters. As a result of following these suggestions, the various companies produced in their gardens many vegetables that were welcome additions to the ordinary Army ration. In many cases the men were advised as to best varieties to plant and as to the most promising methods for bringing the soil into good condition for the growth of food crops. The station was also instrumental in suggesting the best varieties of shrubbery with which to ornament the Army grounds or to camouflage the vulnerable points. The work of the station in connection with the military posts is greatly handicapped by the continual changing of the Army personnel, which makes it practically impossible to carry out any consistent constructive policy of work as to production of food and forage crops. The station members understand, however, that the local Army authorities are trying to arrange for the permanent detail of specialists along food crop, forage crop, and forestry production lines. It is expected that these men will be commissioned and assigned permanently to the task of watching and aiding the different posts and private owners in their efforts to do constructive work toward making the island better prepared for subsistence during war times.

HORTICULTURAL INVESTIGATIONS.

Extending improved varieties of fruits that will prove valuable additions to the resources of the islands has constituted an important line of work of the horticultural division during the year. The solution of the more important problems connected with the experimental stage of the pineapple industry has enabled it to develop until it is second only to sugar in importance in the islands. This success has made it seem practicable for the station to direct to other crops considerable energy formerly given to the pineapple crop. Work in cooperation with the scientific staffs of pineapple companies whose owners are financing stupendous undertakings to solve some of the more recent problems that have arisen in connection with the pineapple industry, has continued. The policy of the station is to focus the major part of its attention upon crops that may prove of importance to the islands, but which have not as yet been developed commercially to the extent where they will enable their producers to carry on private experimental work.

The avocado is one of the important fruits of Hawaii and is capable of great expansion as an industry, provided suitable methods of commercial utilization of the fruit are perfected and proper precautions are taken to protect it from the Mediterranean fruit fly, which interferes with the marketing of the fruit at the mainland ports of the United States. The planting of the avocado should be extended to all parts of Hawaii. This fruit contains approximately 25 per cent fat. During normal times it can be canned, made into paste, or otherwise preserved, and in case of interruption to shipping it can be used to feed the people of the island, taking the place of ordinary fats. The station has made arrangements with some owners for cooperative work in their small avocado orchards. These orchards will furnish facilities for conducting various experiments and also demonstrate what can be done with avocados grown on a commercial scale.

The work with mangoes was limited largely to the extension of the two varieties, the Pirie, a mango introduced from India, and the Victoria, a scarlet-colored mango of obscure origin, but of striking appearance.

The papaya is becoming more and more popular in Hawaii as better strains are developed. The station has three types of delicately flavored papayas. Seeds and seedlings of these were distributed to the public on its semiweekly distribution days during almost the entire year.

The Macadamia nut (*Macadamia ternifolia*) has continued to show its potential value as a supplemental food crop for Hawaii, and extensive cooperative plantings of the seedling have been made in various parts of the three larger islands.

CHEMICAL INVESTIGATIONS.

Members of the chemical division made frequent trips to various parts of the islands during the early part of the year to select locations which would be suitable for a number of cooperative experiments connected with the maintenance of soil fertility and crop production. A rice survey of the islands was also completed.

Rotation and fertility experiments were begun on the island of Maui, one set of plats being located near Haiku and the other at the Haleakala substation some 1,300 feet higher than the Haiku location. The Haiku series consists of a rotation with pineapples, pigeon peas, and sugar cane. The Haleakala series covers a three-year rotation with corn, beans, and potatoes.

A 60-plat triangular system of fertilizer experiments was planned in February, 1919, by M. O. Johnson, at that time chemist of the station, to determine the limit of plant foods required for the best production of bananas and the proper combination of these plant foods. Twelve plats were added to the 60 regular plats to ascertain the effect of additional combinations of different fertilizers at varying rates.

During the year an experiment was begun at the station to discover, if possible, some remedy for the pineapple wilt. The primary object of this experiment was to find toxic substances which would kill the fungus without injuring the tissues of the pineapple plant. Thirty plats, each 0.05 acre in size, were utilized in this experiment. The field work was supplemented by pot cultures having nutrient solutions to which small amounts of the various antiseptics were added. The most promising results were obtained from calcium oxychlorid.

A triangular experiment with pineapples, somewhat similar to the one inaugurated for bananas, was started in the Haiku district.

Experiments in drying and preserving locally grown vegetables and fruits were deemed of such importance as to be continued. The station has cooperated in this work with local canning and preserving concerns which are interested in the manufacture of products from diversified fruits and vegetables in question.

AGRONOMIC INVESTIGATIONS.

The agronomy division continued its variety-testing work, growing various introductions from different parts of the world in comparison with the improved locally grown varieties of field and forage crops. It has been found that many varieties that are adapted to the mainland portion of the United States are not at all suitable for growth at some of the available altitudes throughout the islands. This is especially true of corn grown at the lower altitudes, where the standard varieties brought in from the mainland are almost total failures. On the other hand, corn especially bred for tropical conditions yields nearly 50 bushels of shelled corn per acre at or near sea level, and 100 bushels per acre at 600 feet elevation where the conditions are better adapted to its production. During the year field N, which is just across the road from the station buildings, was replatted and a new cropping system laid out.

A variety test with 9 strains of cassava was conducted, and 13 varieties from Java and elsewhere were added to the variety test during the year.

The potential importance of edible canna as an emergency crop for the island population in time of shipping interruption, its value as a hog feed during normal times, and its possibilities as a starch-producing plant have made it advisable to continue experimental work with it. Large numbers of cooperative plantings have been made on local farms which are favorably situated for its growth.

Two cooperative variety tests with the seven best varieties of sweet potatoes were started during the year. The station's work with forage crops has been principally that of obtaining the most suitable grasses for soiling purposes, since the practice throughout Hawaii is to feed forage crops in the green-cut rather than in the cured stage. This is due to the fact that these crops can be harvested practically every day in the year. The grasses receiving particular attention have been the Merker grass (*Pennisetum merkeri*) and Napier, or elephant grass (*P. purpureum*), which are proving valuable supplements to such fairly well-established crops as the Japanese Uba cane, sorghum, and Sudan grass.

A new cowpea variety of special promise was discovered during the year. This seems to be a hybrid of unknown origin. The crop produced from the station's first crop of seed weighed 4.3 tons of green feed per acre when two months old. A crop of well-matured pods was produced from the second growth of the beans after the first cutting.

PATHOLOGICAL INVESTIGATIONS.

The plant-disease investigations of the station were confined largely to the diseases affecting some of the more important agricultural crops of the islands. The results of the division's observations and investigations concerning the potato diseases in the islands were published in Bulletin 45, "Potato Diseases in Hawaii and Their Control." The preliminary results of the study of some of the local root-rot diseases were published as Press Bulletin 54, "Preliminary Report on Root Rot in Hawaii." These root-rot studies are especially important in view of the fact that the particular root-rot organisms studied seems to be the cause of the Lahaina disease of sugar cane and also of the wilt disease of pineapple. This organism or group of organisms is most important, affecting as it does bananas, rice, and taro, in addition to pineapples and sugar cane.

An experiment in connection with the control of taro rot was begun on Molokai in cooperation with the Bernice P. Bishop estate.

The banana freckle disease continues to be a matter of serious concern to the banana industry, but there seems to be no doubt that proper soil sanitation, pruning, and spraying with Bordeaux mixture will materially reduce the damage to the fruits.

AGRICULTURAL EXTENSION WORK.

Small farming operations continued to develop satisfactorily during the past year. Many of these farms were established since the organization of the extension division five years ago, yet they have been brought to a fair degree of success. The World War was a very efficient factor in promoting the development of diversified industries throughout the islands. In this work the sugar and pineapple plantations rendered effective cooperation and assistance. The Haleakala substation was established for the express purpose of assisting new homesteaders on the Haleakala homestead tract, which was recently opened to settlers. At this substation it is planned to show just what can be profitably undertaken on a typical homestead unit under the conditions present in that part of the island of Maui. The extension division has continued its policy of rendering the greatest possible public service along agricultural lines. During the year a weekly agricultural page was edited for one of the daily papers reaching a large number of people interested in the agricultural development of the islands. During the year the demands for seeds of new varieties and improved strains of various crops was greater than ever before. More than 5 tons of especially selected seed stocks of pigeon peas, sufficient to plant more than 1,000 acres, have been distributed during the past three years. This crop is now well enough established to leave it in the hands of the agricultural public for future production and dissemination of the seed. The increased demand for information from the extension workers has resulted in numerous field trips and much correspondence, while more numerous public lectures have been given than formerly.

HOME-DEMONSTRATION WORK.

The greater part of the station's extension work has been carried out on the islands of Maui and Hawaii, where two members of the extension staff have headquarters. On the island of Oahu the population is centered largely in and around Honolulu, and assistance along agricultural lines is given to a great extent by members of the station's staff who live on the station grounds adjoining the city.

In the home-economics work the wives of some of the station members experiment in their homes to learn the best methods of utilizing various and often little-known fruits and vegetables. These can be substituted for the imported articles. The more promising of these methods are placed before the public by means of the local press, women's clubs, and the like, also by correspondence, personal interviews, and telephone.

EXTENSION WORK ON THE ISLAND OF HAWAII.

Arrangements were made at the beginning of the fiscal year for an extension agent for the island of Hawaii, and R. A. Goff was selected for this position. Mr. Goff also continues to have general charge of the Glenwood demonstration farm, which has been changed from an experiment station to a self-supporting farm. The work of the extension agent was largely that of distributing improved stocks of seed and agricultural literature, inaugurating demonstration plats of improved varieties of forage crops, and holding meetings to discuss agricultural topics. Much assistance was also given to various growers who wanted information regarding suitable markets for their surplus production.

The development of the boy-scout work on the island of Hawaii has called for examinations in agriculture, which have been given by the extension agent. The school and home gardens of 14 schools were visited and assistance was given in carrying on spraying demonstrations. Later the extension agent acted as one of the judges in awarding the prizes. Considerable assistance was also given the Boys' Working Reserve work, which has played an important rôle in the agricultural development of the islands, and which has also been instrumental in developing an appreciation for agricultural work among the growing boys of the community. In a number of instances girls cooperated with the Boys' Working Reserve and rendered very effective assistance along the same or similar lines of work.

HAIKU SUBSTATION.

Climatic and soil conditions on the island of Maui are quite different from those surrounding the central experiment station at Honolulu. It has therefore been found desirable to conduct experiments at the Haiku substation to learn what crops can best be grown there. If successful, these experiments will be repeated in the immediate surrounding agricultural sections. Weather records have been maintained to throw as much light as possible on the behavior of the crops in question.

Pineapple investigations constituted an important phase of the work of this station during the year. The pineapple industry has rapidly extended the planted area to new and untried locations. Results of the fertilizer experiments which were begun several years ago are now available. These will be of practical value to the extended areas now being planted. These experiments were outlined to answer important questions concerning the liming and fertilizing of pineapples and cropping and rotation systems necessary for the most profitable production of pineapples. Other experiments were carried out to ascertain the relative merits of crowns, slips, and shoots (suckers) as planting material and the best methods of preparing them for planting. The cost of grubbing and otherwise preparing the land for pineapples has been found to be about $88 per acre. The experiments in tillage seem to have exerted little or no influence on the yields of the pineapple fruit. Many experiments are being conducted in connection with the culture, fertilizing, harvesting, and utilizing of pigeon peas.

REPORT OF THE HORTICULTURAL DIVISION.

By J. M. Westgate.

During the greater part of the year covered by this report the agronomist in charge had direct supervision of the horticultural work, which was continued along essentially the same lines as in the past. The various kinds of fruit trees that were obtained from different parts of the world were maintained and kept under observation. An important phase of the division's activities was the distribution of improved strains of papayas, tomatoes, roselle, and other food plants. In addition to making these distributions the staff cooperated with many people who are interested in the increased planting of improved varieties of fruits.

AVOCADOS.

The avocado is one of the most popular fruits in Hawaii, where climatic conditions greatly favor its development. The demand for it is usually in excess of the supply, as is evidenced by the high prices paid for the fruit in the local markets. As a result of the introduction of varieties which mature at different seasons and the development of methods for preserving this fruit it is thought that the planting of the avocado tree will show a marked increase within a reasonable time. Its production is especially important to the Hawaiian Islands, because the fruit contains a very high percentage of fat and constitutes an important source of vegetable oil, which could be substituted for the imported oil in time of food scarcity. The development of successful budding and grafting methods has made it possible to establish commercial orchards containing many varieties of avocados.

The station has undertaken cooperative experiments with five growers to hasten the development of avocado commercial planting. Each of these growers has planted an acre or more with the budded seedlings of many suitable varieties so that they will mature at different seasons of the year. The experiment station furnishes the trees and expert advice and instructions regarding the proper methods of handling them. The owner of the land in turn gives the trees the cultivation, spraying, and pruning necessary to insure their best development. The first of these orchards was located with Mr. Carlton Miller, Kaneohe, Oahu, and consists of about two acres of budded varieties and hybrid seedlings. The latter will be budded over later if the seedling fruits prove less desirable than the fruits from the budded trees. Mrs. C. B. Cooper, at Aiea, Oahu, has planted about an acre of budded trees and seedlings which will be budded later. Mr. A. B. Langham and Mr. Walter, both of Aiea, Oahu, have each undertaken the production of an acre of avocado trees under the arrangements mentioned above. Dr. W. D. Baldwin, of Haiku, Maui, has also undertaken the development of a commercial orchard. In addition to budding and grafting trees that he purchased, Dr. Baldwin has undertaken the planting and care of approximately an acre of improved strains. Among the latter are some of the Guatemalan varieties that are adapted to relatively high altitudes. The station has a small orchard of budded local varieties, and its substation on the slopes of Tantalus, which is approximately 1,000 feet above sea level, has a small orchard of the Guatemalan varieties. The local varieties are doing very well, but the introduced Guatemalan varieties are not developing as it was hoped they would. This is probably due to the altitude of the Tantalus substation, which is from 3,000 to 5,000 feet lower than elevations from which these varieties came. This orchard should make possible valuable observations on the varieties and their behavior under Hawaiian conditions and show which of them are worthy of extended planting. It should also serve to supply a large amount of budwood for further propagation of avocados which give promise of becoming standard varieties. The Guatemalan varieties will be extended as rapidly as a supply of budwood is available from the small trees recently received from the Office of Foreign Seed and Plant Introduction, U. S. Department of Agriculture, Washington, D. C. It is intended to give the Guatemalan varieties a thorough trial at the higher elevations throughout the islands. Plans have been made for the introduction and testing of five standard varieties agreed upon by the California avocado growers as being the most practicable varieties upon which to concentrate their efforts, especially for commercial production. These varieties are Fuerte, Spink, Dickinson, Sharpless, and Puebla.

MANGOES.

The variety test of various mangoes has indicated that probably the Pirie is the most promising mango for Hawaii. This mango comes from India, where it has long been cultivated and where its superiority over other varieties is recognized. The honor of having first brought this variety to Hawaii is due to Mr. Samuel Damon, who imported this and other varieties from India at great expense. Mr. Gerrit P. Wilder, who has always been an enthusiastic worker in improving Hawaiian fruit, was also instrumental in making an early introduction of the Pirie and other varieties. Some of these varieties came from the United States Department of Agriculture. The Pirie variety has been introduced by the station at various times under different names, such as "Strawberry," "Peter's No. 1," and the like. Fruits acquire new names in different parts of the world. This variety is known in and about Calcutta as the Bombay mango, because it came to Calcutta from Bombay.

The Pirie mango has been under cultivation in and about Honolulu for 10 or 15 years, and has been found well adapted to conditions prevailing here. There are not sufficient data available to show what it might do at elevations of several hundred feet, but probably it will succeed on the lowlands of any of these islands as well as any of the established varieties of mangoes. Mr. Donald MacIntyre, of the Moanalua gardens, states: "The Pirie is the mango for Honolulu." Mr. A. B. Langham, of Aiea, who has cultivated this and other varieties of mango in India, states that the Pirie mango here is equal to any that he saw in India.

In order to bring home to the Hawaiian public the desirability of extending the production of the Pirie, an arrangement was made with the Honolulu Ad Club to serve this mango at one of its regular luncheons. The result of this demonstration was that the Ad Club immediately undertook to extend the variety, publishing and distributing a pamphlet which set forth the desirable features of the fruit. The pamphlet carried a colored illustration clearly indicating the excellent appearance and other desirable characteristics of the Pirie, especially the freestone nature of the seed. The publication as well as the station staff laid emphasis on the fact that old seedling trees of little present value can be grafted over to the Pirie variety. The station has distributed budwood and scions for carrying on this work. Two mango propagators have been at work in budding the various seedling trees to this variety. In addition to its exquisite flavor and lack of stringiness, the Pirie is practically immune to the ravages of the Mediterranean fruit fly. This fly frequently attacks the ordinary seedling mangoes to a disastrous extent, and the resulting maggots render the fruit unfit for eating. The Pirie is also less subjected to the black-spot disease than many of the locally grown varieties.

Some attention has been given to the extension of the Victoria mango. The outstanding characteristic of this fruit is its scarlet color which makes it a most pleasing addition to any collection of fruit. The aroma is exquisite and the flavor is good. There is more of a tendency to stringiness of the flesh than is the case with the Pirie variety, and the stone is not of the freestone quality. The parent tree is growing in the yard of Mr. Thomas G. Thrum, Honolulu, and some two dozen seedlings from this original tree have been successfully started and will be budded in part with buds from the parent tree. One branch of each seedling will be permitted to mature fruit to obtain, if possible, an improvement in the quality of the flesh without losing the remarkable color and aroma of the present fruit. This variety, like the Pirie, is practically immune from attacks of the fruit fly.

PINEAPPLE SEEDLINGS.

The cooperative work in connection with the growing of pineapple seedlings has been continued. Plantings were made at Kunia with the Thomas Pineapple Co.; with the Hawaiian Pineapple Co. at Waikakalaua; and with Libby, McNeill & Libby at the old Thomas homestead at Wahiawa. The plantings with the Thomas Pineapple Co. at Kunia began to bear fruit during the summer of 1919. The fruit of the first crop can not be taken as a fair index of what may be expected from the plant later, owing to the fact that the seedling pineapple has a long, hard struggle in becoming established. A true index of the producing abilities of a given plant can best be obtained by making plantings of suckers, slips, and crowns from the fruits obtained from the original seedlings. The seedlings at Waikakalaua have shown a great deal of variation in vigor and the like, but a considerable number of them appear promising. It is characteristic of pineapple seedlings to vary in size, shape, color of foliage, spininess of the leaves, and in other ways. Seedlings that have been raised in the greenhouse should be placed on benches in the open for a few weeks prior to transplanting them in the field so that they may become properly hardened.

PAPAYAS.

The station's work with papaya has been confined to the propagation of improved strains of edible varieties of papayas. Among these the Solo variety stands out as the best flavored of any that have been under test. There has been considerable demand, however, both for the long and the round varieties. The station continued to make extensive distribution of both seeds and seedlings of these three classes of papayas. The Solo papaya is oblong in shape and averages about 4 inches in diameter and 6 inches in length. The seedlings from this variety come remarkably true to type. The fruits are filled with seeds which are easily removed. These features make the propagation and extension of this variety a comparatively easy matter. Since the trees do not grow very tall, it is possible to gather the fruit without the use of a stepladder.

GRAPES.

Cooperative experiments with grapes at Wahiawa were continued during the year. This work was undertaken in cooperation with Mr. Willard Brown, but his absence from the Territory made it necessary for the station to attend to much of the actual management of the vineyard. The grapes were successfully brought into bearing during the summer of 1919. It has been found that the plants require applications of phosphoric acid and nitrogen for their best development, and that they will probably need some form of potash as they continue to fruit. The present recommendations to the owner of the vineyard call for the annual application of steamed bone meal at the rate of 544 pounds per acre, or 1 pound per plant, and dried blood at the rate of 408 pounds per acre, or three-fourths pound per plant. This experiment is of special interest because different varieties of grapes have been under test, though the purple Isabella variety is practically the only grape grown on the islands.

STRAWBERRIES.

In the Hawaiian Islands strawberries are usually grown only at elevations of 1,000 feet or more. If proper precautions are taken, however, good strawberries can be grown at sea level. A comparatively simple method is to raise them in a barrel which is filled with properly prepared soil. (Pl. I, fig. 1.) The strawberry plants are planted in holes arranged at suitable intervals in the sides of the barrel. The barrel can be placed on sled runners so that it can be shifted to a shady place when the summer's sun gets too hot. The following is a description of this method of production:

A 50-gallon barrel should be used if possible, and holes 2½ inches in diameter should be bored at 9-inch intervals 6 inches from the top of the barrel. A second ring of holes should then be bored 8 inches below the first set, the latter holes being 12 inches apart. A third set of holes should be bored 8 inches below the second set. These should be about 9 inches apart. Five holes should be bored in the bottom of the barrel for drainage.

One-fourth of a barrel of leaf mold should be mixed with three-fourths of a barrel of potting soil. The potting soil is made by mixing together one part of black sand, one part of manure, and two parts of ordinary dirt. After the soil and leaf mold are thoroughly mixed, some gravel or broken rock should be put in the bottom of the barrel to a depth of about 3 inches. The mixed soil should then be put into the barrel and the strawberries planted in the holes as the barrel is being filled with dirt. After planting the sides 6 strawberry plants may be planted on top of the barrel. The plants should be watered once a day from the top, and the strawberries should be picked as they ripen. A number of these barrels can be utilized if desired, and they will be found to occupy comparatively little space considering the returns they bring.

MACADAMIA NUTS.

At the Tantalus substation there are three Macadamia nut trees in bearing. These have produced very satisfactory crops of delicious nuts. Several other Macadamia nut trees have been under observation in different parts of the islands, and the general success had with them seems to indicate that much more extensive plantings should be made. Several hundred seedlings have been produced and either planted out on the larger islands or still remain in the pots at the station to await transplanting. (Pl. I, fig. 2.)

The Macadamia nut is about five-sixths inch in diameter and has a comparatively thin but very tough shell. The meat is solid, spherical in shape, and of somewhat the same quality as the meat of the Brazilian nut.

DISTRIBUTION OF SEEDS AND PLANTS.

One of the primary objects of the experiment station is to foster the growing of food plants of all kinds. The ordinary householder often finds it difficult to start into growth the seeds of a number of plants and he has better success with transplanted seedlings. The station renders much service to the public by maintaining for distribution a supply of seedlings of various fruit plants in season. Care is always taken to confine this distribution to improved varieties which the station wishes to have widely disseminated. The most extensive distributions have been made of improved papaya plants and hybrid tomato plants which were bred especially for resistance to melon fly attacks. The fly attacks the ordinary variety of tomato and often renders it unfit for use.

PACKING PLANTS FOR SHIPMENT.

In the Tropics where there is virtually no resting stage comparable to the winter resting of plants in the Temperate Zones the problems of preparing plants for shipment is decidedly complex. To make success reasonably sure, the plants must be in vigorous condition and the entire foliage removed just before they are packed. The quarantine regulations for shipments to the outlying islands require that every particle of soil must be washed from the roots. The plants are then fumigated and packed in moss which is moistened sufficiently to remain damp during transit. In packing the plants just enough moss to cover the seedlings should be used. The roots and tops should then be wrapped in waxed paper, and this in turn with thick manila paper. Different proportions of moss and water are desirable for use in packing different kinds of soft-root seedlings. Eight ounces of moss wet with 16 ounces of water has been found desirable for packing seedlings of Macadamia nut, papaya, roselle, citrus, and tomato. The seedlings of mango, avocado, litchi, and coffee trees require 2 ounces of moss moistened with 16 ounces of water.

GRAFTING WAX FOR HAWAIIAN CONDITIONS.

The extension of improved varieties of fruit trees often necessitates grafting the improved varieties on mature seedling trees. This requires the use of grafting wax. The ordinary wax imported from the mainland has not been found satisfactory for use in Hawaii. Climatic and other conditions here vary greatly from those in America or Europe, and different grades of grafting waxes must be employed. By experimenting, P. K. Lee, of this station, has developed a wax that is especially suitable for tropical countries. It contains the following ingredients: One part tallow by weight, 8 parts beeswax, and 4 parts resin. This wax possesses a high melting point (about 120.5° F.) and has excellent staying qualities. It is also very ductile and tenacious, adhering to the wound until the latter is entirely healed. It is an excellent wax for the tropical countries on account of these qualities; it not only prevents any exposure in wounds or stubs, but, owing to its cohesive power, it hastens and insures union in grafting. This is not apt to be the case when the wax is prepared from the mainland formulas. Moreover, when being applied, the station wax does not stick to the hands like waxes which are made by the usual formulas. If a softer grade of wax is desired the following formula is suggested: Two parts tallow by weight, 8 parts beeswax, and 4 parts resin. This wax, while very similar to the other, has a lower melting point (about 119° F.). It is softer and hence is very suitable for greenhouse grafting or for the cooler seasons.

SPRAYING AND PRUNING DEMONSTRATION.

Insect enemies and plant diseases are at work continuously throughout Hawaii. This necessitates repeated sprayings to maintain the yields of many of the different kinds of fruits now grown. The station orchards have been sprayed as needed. These sprayings in part were in the nature of demonstrations of the best methods of overcoming insect pests and diseases.

Effective spraying depends upon its thoroughness. The application must be liberal and the pressure powerful enough to cause the spray to settle on the trees as a fine mist instead of in large drops. A power duplex sprayer, having the nozzles elevated upon bamboo poles, has been very satisfactory for use at this station, because two lines of hose could be used at the same time.

A proprietary oil especially designed for the San José scale is used for aphids, mealy bugs, and Florida scale insects. A number of experiments were carried on to determine the degree of concentration which would be most effective. For all cases, 1 part of the above-mentioned oil to 30 parts water by quantity has been found to be the most effective.

The use of a nicotine-sulphate spray containing the following ingredients is recommended for mites: One pint nicotine sulphate, 1.75 pounds whale-oil soap, and 50 gallons water. As the trees in the islands are usually attacked at the same time by aphids, mealy bugs, scale insects, and the like, the proprietary oil and nicotine sulphate may be mixed together as follows and sprayed all in one: One gallon proprietary oil, 30 gallons water, and 6 or 7 ounces nicotine sulphate. This is sufficient to spray 20 trees 10 feet high. The use of this combined spray economizes labor and materials, because the whale-oil soap can be eliminated. To secure a thorough control a second spraying should be given after a period of about 10 days.

Some diseases do not lend themselves readily to spraying. Among these is the gummosis disease, the cause of which is still doubtful. This disease is characterized by the exudation of a gummy sap on the trunk of the tree from the point of budding up to a rather limited height. Methods of spraying have been tried, but none has given complete satisfaction. No cure has been found for the tree where the disease has encircled the trunk. In such cases the whole tree should be removed. In less serious cases the bark should be stripped off from the affected area and a mixture of creosote and pine tar applied.

Fruit trees not only need spraying at suitable intervals, but should also be pruned. During the spring of 1920 the orchards were thoroughly pruned and sprayed. In pruning the citrus trees care was taken to remove inside limbs without spoiling the natural symmetry of the tree. After pruning, all cut-off branches were burned to re-

PLATE I.

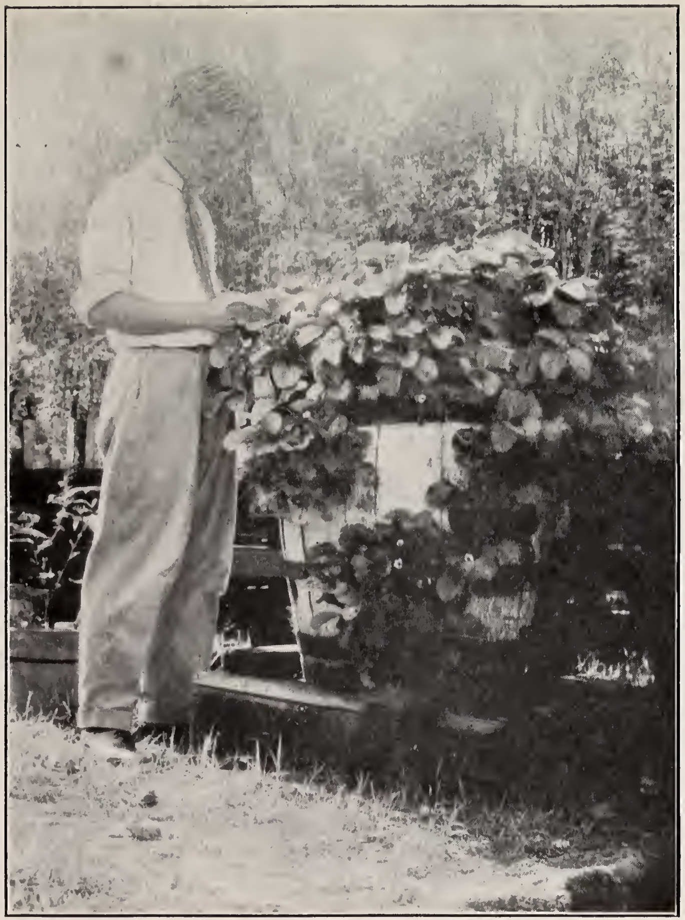

FIG. I.—GROWING STRAWBERRIES IN A BARREL.

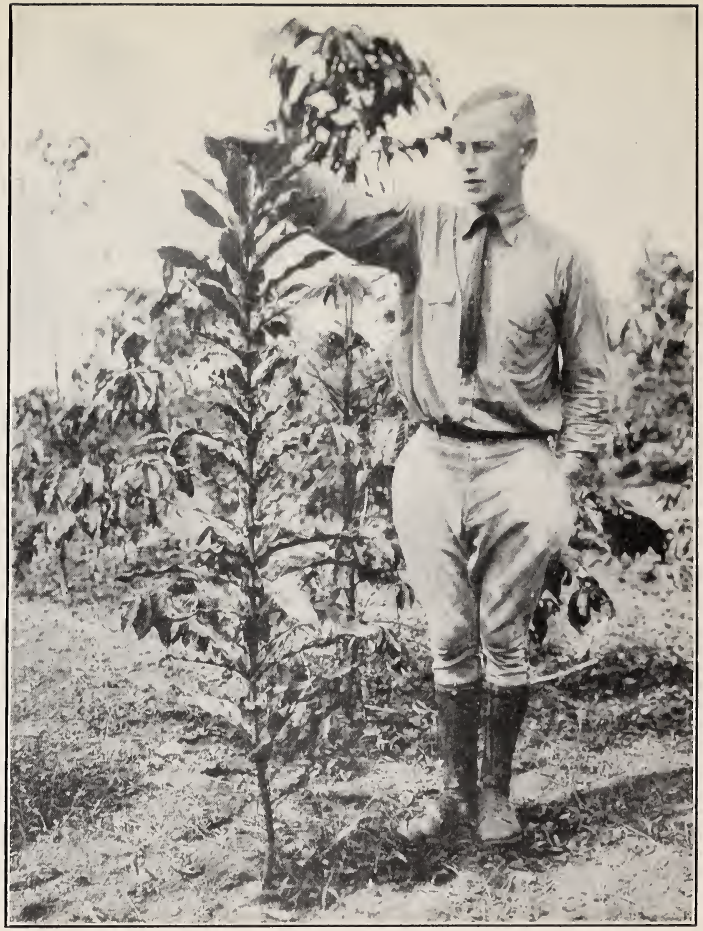

FIG. 2.—MACADAMIA NUT TREE ONE YEAR OLD.

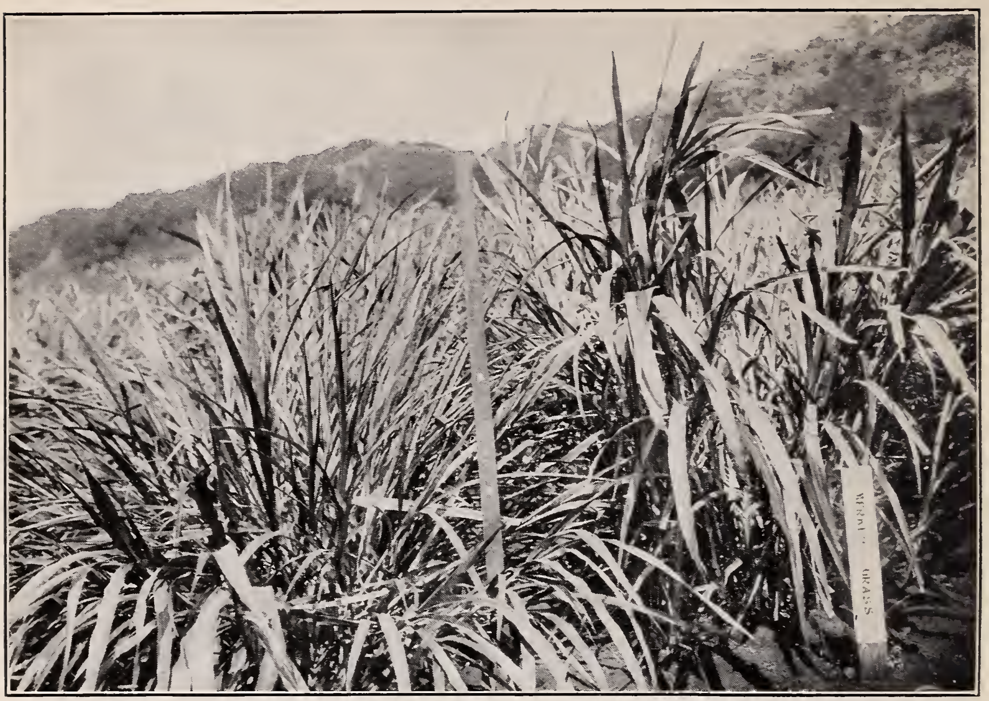

FIG. I.—MERKER GRASS 30 DAYS OLD.

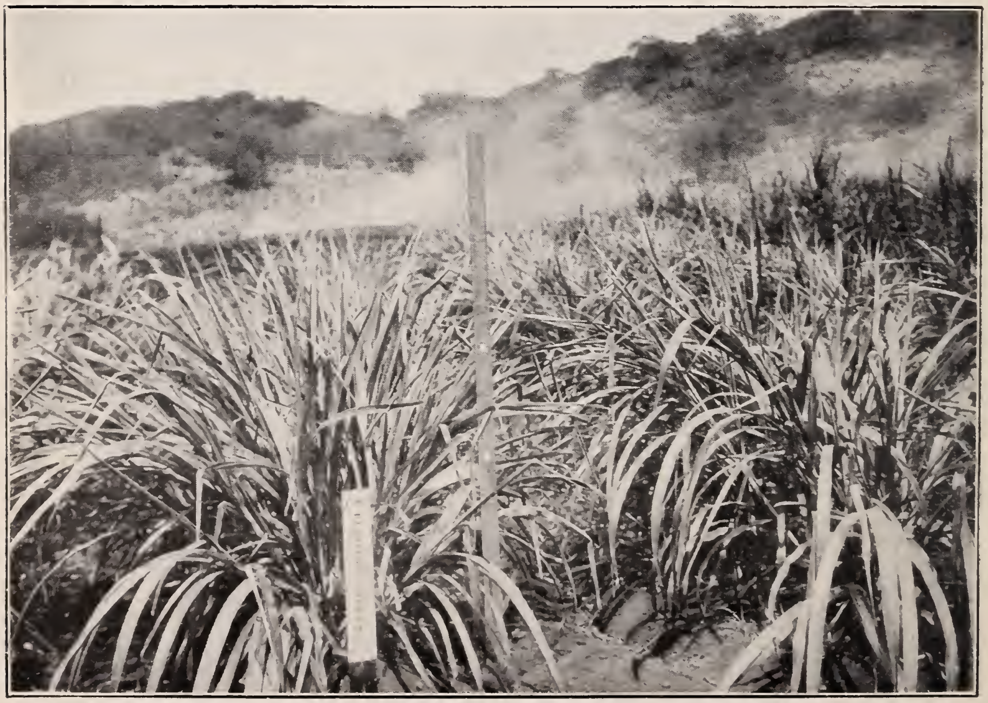

FIG. 2.—NAPIER OR ELEPHANT GRASS 30 DAYS OLD.

duce the danger of spreading disease. The best time to prune citrus orchards seems to be immediately before the blooming season. Pruning shears, saws, and chisels should be well sharpened so as to produce a smooth cut which will rapidly heal. This will retard the entrance of fungi which might otherwise cause trouble.

A DEVICE FOR SECURING BOTTOM HEAT IN THE PROPAGATION OF CUTTINGS.

It is a well-known fact among gardeners and horticulturists that many cuttings require bottom heat to produce roots freely. The need of this treatment is not as universally recognized in the Tropics as it should be. The soil or sand in the cutting bed is likely to be cold and not conducive to the production of roots in the cool season, though the tropical sun may keep the tops of the cuttings quite warm. Some method of securing bottom heat is very desirable. Fresh stable manure may be used to generate heat as is done in hotbeds in northern climates, but it is not wholly satisfactory in the Tropics. A device has recently been made by this division to secure the benefit of the sun's rays where heat is needed beneath the plants. (See fig. 1.) This device consists essentially of a box, the major part

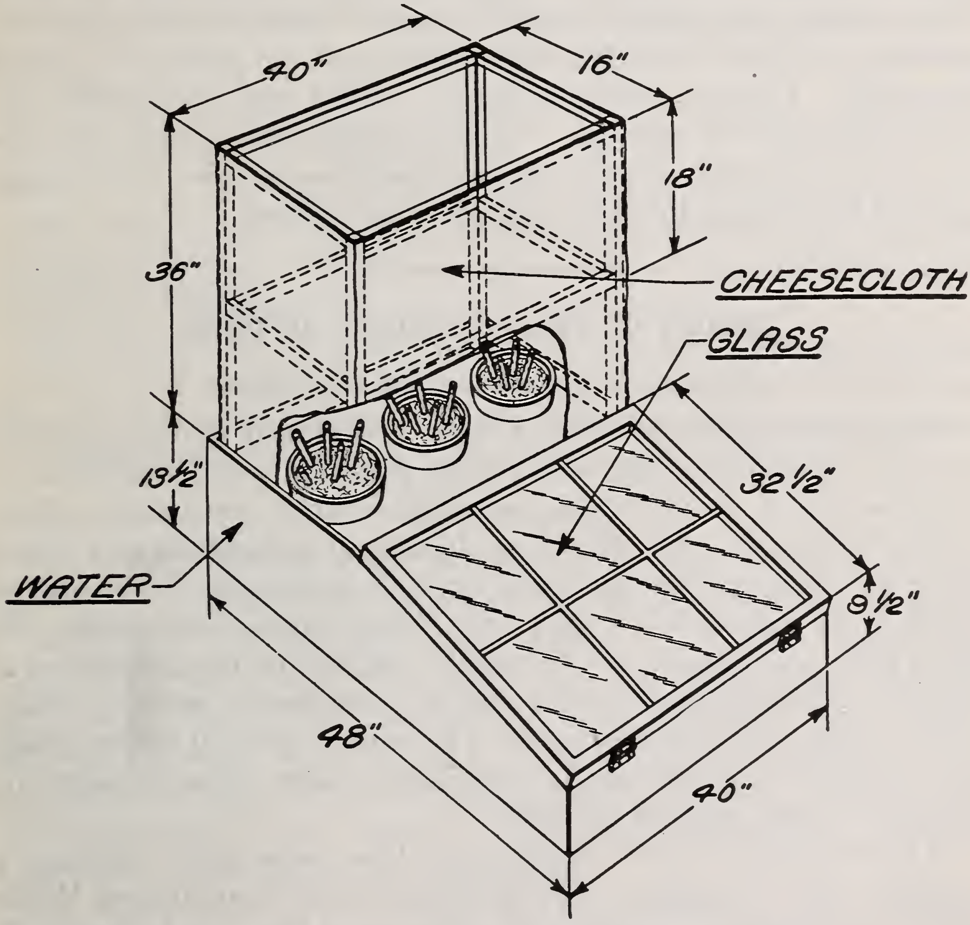

FIG. 1.—Device for securing bottom heat for root cuttings.

of which is covered with a closely hinged glass cover. The remaining part of the box is covered with a 1 by 12-inch board through which holes are cut to admit the pots. These are dropped into the box as far as the rim. The bottom of the box may be zinc lined and filled with water to a depth of several inches, or it may be filled with black-painted bottles full of water. The sun's rays upon the water or upon the black-painted bottles through the glass cover generate a large amount of heat which is retained by the water at an approximately uniform temperature throughout the night. The hinged top may be closed or opened slightly according to the needs. The cuttings are placed in sand or other material in the pots, the bottoms of which are filled with broken rock or pottery to provide drainage. A frame, which is partly covered with cheesecloth, provides shade for the cuttings. Openings at the end permit free passage of the air and prevent the accumulation of heat in the upper part of the propagation box where it is not desired.

REPORT OF THE AGRONOMY DIVISION.

By WALLACE MACFARLANE and H. L. CHUNG.

One of the principal lines of work undertaken by the agronomy division during the year was the propagation and distribution of material which would tend to make the islands independent of imported foodstuffs. The Hawaiian Islands at present depend largely upon the mainland and Australia for their foodstuffs. Investigations carried out include work with root, forage, and cereal crops. The local soils and climate are favorably adapted to the production of starches. Promising crops for starch manufacture include cassava, edible canna, and sweet potatoes. The improvement of native grasses and legume crops and the introduction of new varieties have constituted a large part of the work.

Approximately 16,000 cuttings of Uba cane, 4,500 cuttings of cassava, 1,500 cuttings of Napier grass, and 500 cuttings of Merker grass were made and distributed throughout the islands during the past year. In addition to this, 150 pounds of selected Guam corn seed was distributed.

Cereal investigations were confined largely to corn. Guam and Cuban Red are the two most promising varieties for Oahu. The standard varieties of the mainland do poorly here unless grown on lands at the higher elevations. The mainland varieties are more susceptible to diseases than the Guam, Cuban Red, and native corn.

Cowpeas, pigeon peas, and beans have been found to be valuable crops for green manuring and feeding purposes. A number of variety tests have been conducted with these crops for several years and the best varieties for local conditions have been fairly well determined.

CASSAVA.

A varietal test with cassava was begun during the early part of 1918. The results obtained represent the average yield. They are given in the following table:

Tests of cassava varieties.

Row No.	Variety No.	Yield of roots per acre.	Row No.	Variety No.	Yield of roots per acre.
		Tons.			*Tons.*
1	1227	13.60	4	1315	5.00
2	1228	7.75	9	1381	6.53
7	1229	9.25	3	1385	7.34
5	1230	9.50	6	1386	4.89
8	1231	5.71			

The cassava varieties used for the above test were all from the Philippine Islands with the exception of Nos. 1385 and 1386, which came from Florida.

The varietal test is being continued with 13 additional varieties received from Java and the United States Department of Agriculture. The varieties from Java were collected for this station by Prof. J. F. Rock, when he was botanist of the College of Hawaii.

EDIBLE CANNA.

The investigations for the past year with edible canna were confined to a fertilizer test with manure, and the determination of starch content of the different aged canna tubers. The latter project was designed to determine at what age or period of growth after planting the tubers will yield the maximum amount of starch. This experiment is well under way so far as growing the tubers is concerned, but the project has been temporarily suspended owing to the resignation of both chemists of the station. Further cooperation of a chemist is necessary to conclude the investigations.

The following table is a comparison of the results of the fertilizer test carried on with edible canna for the past two years:

Results of fertilizer test with edible canna.

[Yield of tubers per acre.]

Treatment.	Planted Aug. 18, 1918; harvested May 11, 1919.	Planted Sept. 24, 1919; harvested June 7, 1920.
	Tons.	*Tons.*
Manure, 20 tons per acre	21.50	23.60
Check	18.75	20.83

The cultural methods used for the above-mentioned fertilizer tests were the same. Each plat was irrigated three times and given one cultivation during its eight and one-half months of growth.

SWEET POTATOES.

The sweet potato varieties at this station have been finally reduced to seven kinds. To secure further data on their behavior and adaptability under different soil conditions they have been planted in two localities on the island of Oahu. This project was begun in March, 1920, having been made possible through the cooperation of the Kahuku ranch at Kahuku, and Mr. Charles Bellina, of Niu.

IRISH POTATOES.

During the early part of the fiscal year seasonal conditions were very favorable for potato growing. The station and small truck gardeners in and around Honolulu harvested good yields without the aid of spraying. The truck gardeners use California potato seed to a large extent.

The two varieties of potato grown at the station were the Netted Gem, Nos. 1322 and 1320. The former was received from F. G. Krauss, superintendent of extension work, who discovered it as a mutant among his Burbank potato plants. The latter is a potato of unknown origin and variety and was obtained from the Honolulu market. It has been grown with success at this station for two seasons. Both varieties were under test for their blight-resistant qualities. Netted Gem No. 1322 yielded 60 bushels and Netted Gem No. 1320 80 bushels per acre, though neither variety had been sprayed. While these are comparatively good yields, they are by no means proof that the varieties are blight resistant. The favorable seasonal conditions previously mentioned may have been instrumental in causing the good yield. An interesting feature of the potato blight resistance test was the soundness of some of the No. 1320 potato seed tubers. They were still fresh and showed no decay after remaining in the soil for two months and producing a crop of potatoes.

CORN.

Considerable time was devoted to carefully selecting Guam corn for improvement. The result of this undertaking has been encouraging. The average ears from the selected stalks are far better than the original ears received by this station. The yield, however, did not come up to expectations. The selection of the best Guam ears, conforming nearest to the ideal corn types, necessitates sacrificing the length and circumference of the ears for firmness, straightness of rows, and well-filled tops and butts.

A lot of Guam corn seed was received by this station from Mr. Glen Briggs, agronomist of the Guam Experiment Station, who selected and brought the seeds to Honolulu in person. The Guam seed when planted at the Hawaii station made a yield considerably below that of locally grown seed of the same variety. The difference in yield was due largely to the environmental conditions. The Guam station seed was slow in coming up. When the stalks were one month old they were only two-thirds as high as those from locally grown seed. Both were vigorous growers.

The following table is a summary of the comparative yields of the two strains of Guam corn, the Guam grown and Hawaiian-grown corn:

Comparative yield of Guam corn from seed grown in Guam and Guam corn seed grown for several generations in Hawaii.

Strain of Guam corn.	Yield of shelled corn per plat.	Acre yield.	Time of maturity.
	Pounds.	*Bushels.*	*Days.*
Guam-grown seed	51	9.4	107
Hawaiian-grown seed	85	22.9	120

Golden Bantam corn, which was received from F. G. Krauss, was planted on February 10, 1920, and harvested on May 22, the period of growth covering 102 days. The stalks grew vigorously until the appearance of the corn leaf hopper (*Peregrinus maidis*). One-fourth of the stand succumbed to the ravages of this pest before it was three weeks old. The sturdy stalks remaining each produced from two to four small ears. The yield was at the rate of 9.1 bushels to the acre. The yield of this corn is comparatively low, principally because of the smallness of the ears. There is great demand for it as a poultry corn in Hawaii. Its attractive golden color and small-sized kernels have caused corn buyers to select this corn in preference to other varieties. It is hoped that this variety will eventually be improved in regard to its yielding quality.

GRASSES.

The Merker (*Pennisetum merkeri*) and Napier (*P. purpureum*) grasses continue to be the best grasses as sources of green feed for live stock. (Pl. II, figs. 1 and 2.) This was evidenced by the demand for these cuttings, especially for the latter variety. The Merker grass, which is not so well known as the Napier grass, appears to be more drought resistant, a ranker grower, and a heavier stool producer than the Napier grass. The yield per acre for the first cutting after two months from date of planting was 13.05 tons for the Merker grass and 10.05 tons for the Napier grass for the same period.

The yield of the Napier grass compared very favorably with the yield of this same grass obtained by the Rhodesia Experiment Station.[1] After the trial of three continuous months the Rhodesia Experiment Station secured 12,100 pounds as the best yield per acre, while the Hawaii Station obtained 20,100 pounds as the best yield per acre for a growing period of three months.

The following new grass seeds were received for trial planting from the United States Department of Agriculture during the past year: Java grass (*Polytrias diversiflora*), S. P. I. No. 32111; Hunan grass (*Eremochloa ophiroides*), S. P. I. No. 46675; carpet grass (*Paspalum compressum*), F. H. B. No. 8790; and Guatemala grass (*Tripsacum laxum*), S. P. I. No. 47396.

Panicum antidotale, S. P. I. No. 32452, received from Mr. J. B. Thompson of the Florida Agricultural Experiment Station, proves to be a very promising grass as far as the yield under dry conditions is concerned. During the year it yielded at the rate of 11.89 tons of green feed per acre for a growing period of 8 months without irrigation.

The Wonder Forage crop, obtained from a Pacific coast seed establishment, was received for trial planting at this station. The grass seems in physical appearance to be intermediate between Sudan grass and the African sorghums. It is likely that it will produce a larger yield than Sudan grass when irrigation can be had. It is a grass that should be given a trial by all local dairymen. An average of 9.1 tons of green feed per acre per cutting has been obtained by this station.

In addition to the above-mentioned grasses two varieties of grain sorghums were introduced into Hawaii from the Oklahoma Agricultural Experiment Station. While the growth of these two sorghums has not proved superior to the African sorghum No. 309 of this station, it has been very uniform, and they seem to be drought resistant.

The following table gives the results of the test of the two grain sorghums in comparison with the African variety as green feed. These were grown on adjoining plats, each plat containing 1,072 square feet:

Results of a test of varieties of sorghums as green feed.

Variety.	Yield per plat.	Yield per acre.
	Pounds.	*Tons.*
Darso	55.75	1.13
Black hull white kafir	120.00	2.43
African sorghum No. 309	180.00	3.50

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[1] The Rhodesia Agricultural Journal, Vol. XVI, No. 6, p. 541.

COWPEAS.

A cowpea variety of special merit, but of unknown origin, was received by the assistant agronomist at the close of the second Territorial fair in 1919. Four pods were shelled and the peas were found to range in color from straw to pink. This cowpea was thought to be a hybrid and was planted at the station. It made luxuriant growth, the vines forming a mat-like mass, which spread over a wide area. The yield of this cowpea as a soiling crop was estimated at 4 tons to the acre when three months old. The seeds obtained from this planting had the same colors as those mentioned above. When two handfuls were counted, 800 were found to be pink; and 285, straw or light cream in color. This approaches the Mendelian ratio fairly closely. The second planting from the station-grown seed produced 4.3 tons of green feed per acre when only two months old. (Pl. III, fig. 1.)

Data obtained from these two plantings of cowpeas show that it is a rank grower, produces a second crop of beans from ratoons, and remains green much longer than the other varieties tested at this station.

GARDEN BEANS.

A comparative yield test was made of the Early Refugee variety No. 1150 and Liberty Blue No. 1250 to determine the productiveness and edible qualities of each. The latter variety was discovered as a mutant of the former variety.[2] The following table summarizes the results of the investigation:

Yield of beans of Early Refugee No. 1150 and Liberty Blue No. 1250.

Variety.	Yield per acre of green pod beans.	Yield per acre of shelled beans.
	Pounds.	*Pounds.*
Early Refugee	2,381.7	369.50
Liberty Blue	2,823.6	363.88

It will be noted that the yield of the Liberty Blue as a green pod bean exceeded the Early Refugee variety by 441.9 pounds, but it was slightly below in yield as a shelled bean variety. This difference was due largely to the fact that the Liberty Blue variety is a more succulent bean. The water content is consequently higher than is the case with the Early Refugee variety. The Liberty Blue is much preferred to the Early Refugee variety as an edible because of its superior flavor.

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[2] Hawaii Sta. Rpt. 1919, p. 45.

CASTNER SUBSTATION.

Work with forage crops at the Castner substation was officially terminated shortly after the beginning of the fiscal year. The work of this substation may be summarized as follows: Since June, 1916, there have been planted at the substation 23 kinds of grasses, 8 kinds of legumes, and 6 kinds of root crops. After a thorough test covering a period of three years, the following crops have been found to be well adapted to the Castner conditions:

Grasses: Rhodes grass (*Chloris gayana*), Merker grass (*Pennisetum merkeri*), Napier grass (*P. purpureum*), Natal redtop grass (*Trichlolæna rosea*), Australian water grass (*Paspalum dilatatum*), molasses grass (*Melinis minutiflora*), Giant Bermuda grass (*Cynodon dactylon*), Tunis grass (*Andropogon sorghum*). Legumes: Pigeon pea (*Cajanus indica*), annual white sweet clover (*Melilotus alba annua*). Roots or tubers: Cassava (*Manihot esculenta*), edible canna (*Canna edulis*), field carrots (*Daucus carota*).

The Merker and Napier grasses have been found to be the best fodder crops for the Wahiawa district. The Rhodes, Australian water, and Natal redtop grasses are well adapted as meadow grasses, the latter particularly so. (Pl. III, fig. 2.) These grasses can be readily grown in new places from seeds which are disseminated by the wind.

REPORT OF THE CHEMICAL DIVISION.

By Wallace McFarlane and Kim A. Ching.

The work of the chemical department during the past year consisted mainly of rotation and fertilizer experiments, pineapple-wilt investigations, and miscellaneous analyses. Cooperative projects were started with growers on the islands of Oahu, Maui, Hawaii, and Kauai. Requests were received for cooperative experiments on the islands of Molokai and Lanai, but no projects were started there owing to limited funds for carrying on such work. To further these experiments the men in the chemical division traveled over 20,000 miles during the year, and analyzed over 100 samples of soil for the essential plant food elements. In addition, 30 samples of feeding stuffs and 100 samples of miscellaneous products were analyzed. A rice survey of the islands of Oahu, Kauai, Hawaii, and Maui has been completed.

FERTILITY-ROTATION EXPERIMENTS.

The purpose of these experiments was to find the best method of cropping and fertilizing the impervious pineapple soils of Maui. A survey was made in cooperation with F. G. Krauss and W. A. Bald-

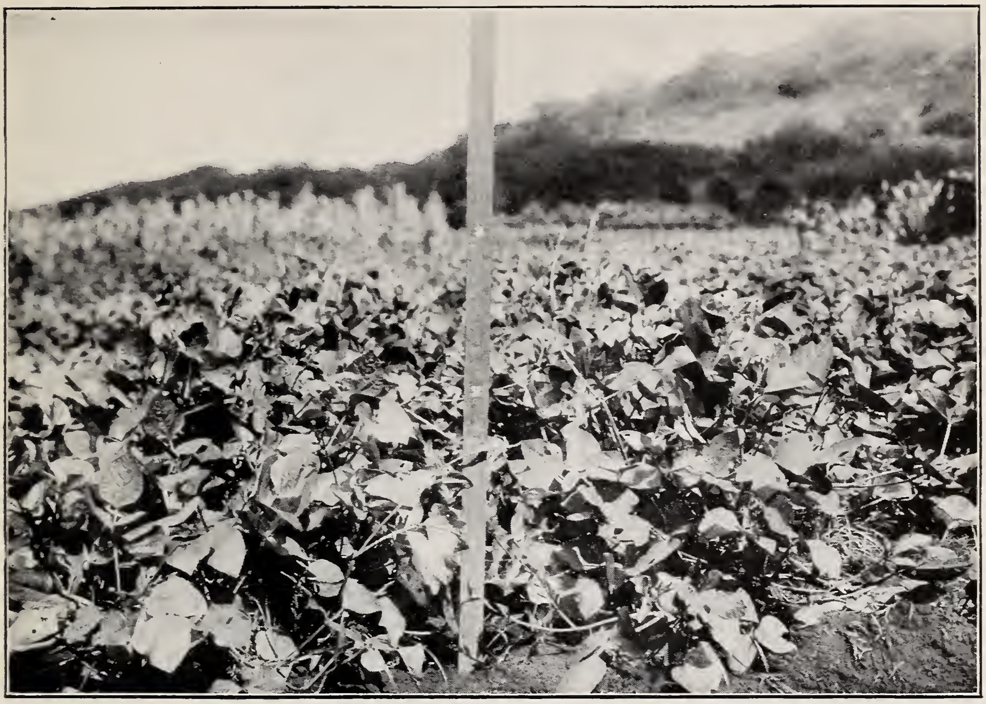

FIG. 1.—A FIELD OF COWPEAS, NO. 1383, TWO MONTHS AFTER PLANTING. THE ROWS ARE 4 FEET APART.

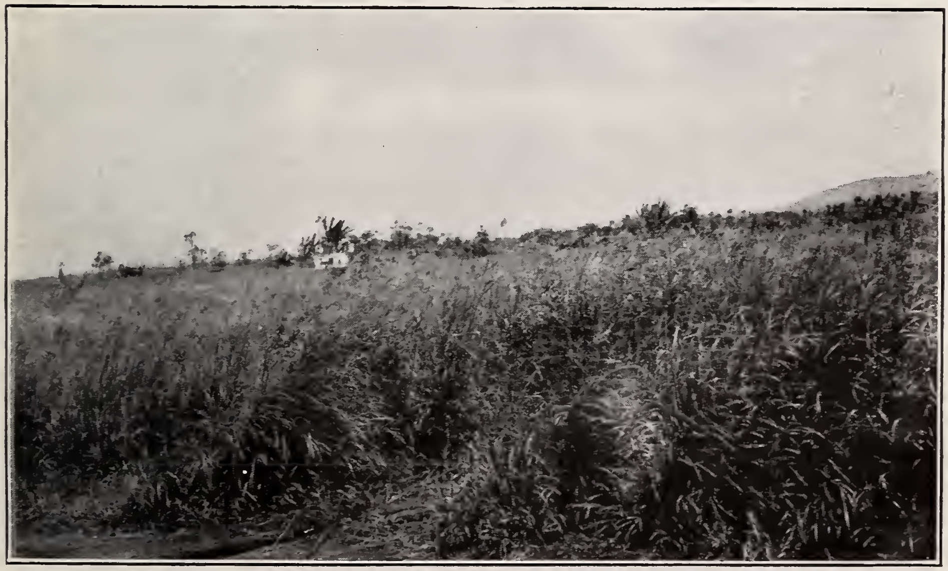

FIG. 2.—A VOLUNTEER STAND OF RHODES GRASS, MILITARY RESERVATION AT CASTNER.

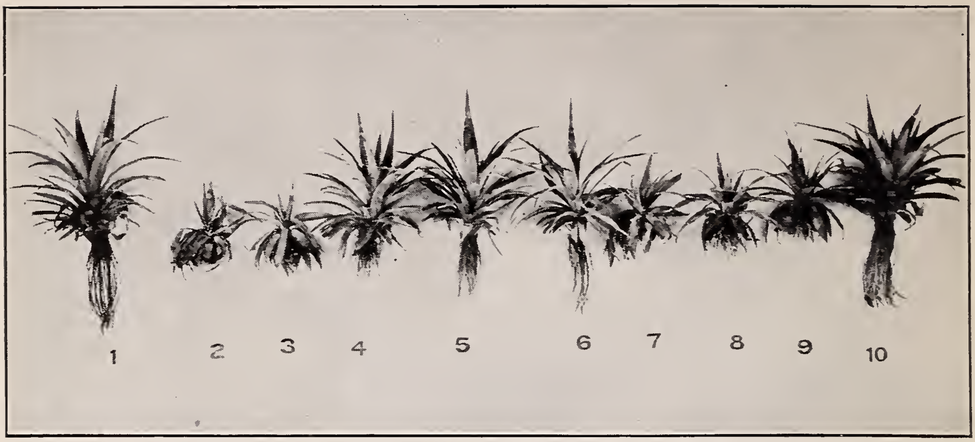

FIG. I.—PINEAPPLE SHOOTS SHOWING EFFECT OF ANTISEPTICS IN NUTRIENT SOLUTIONS.

1, Nutrient solution; 2, copper sulphate (1–1,000); 3, copper sulphate (1–10,000); 4, copper sulphate (1–25,000; 5, copper sulphate (1–50,000); 6, copper sulphate (1–100,000); 7, corrosive sublimate (1–10,000); 8, corrosive sublimate (1–25,000); 9, corrosive sublimate (1–50,000); and 10, calcium oxychlorid (1–5,000). Photographed one month after starting experiment.

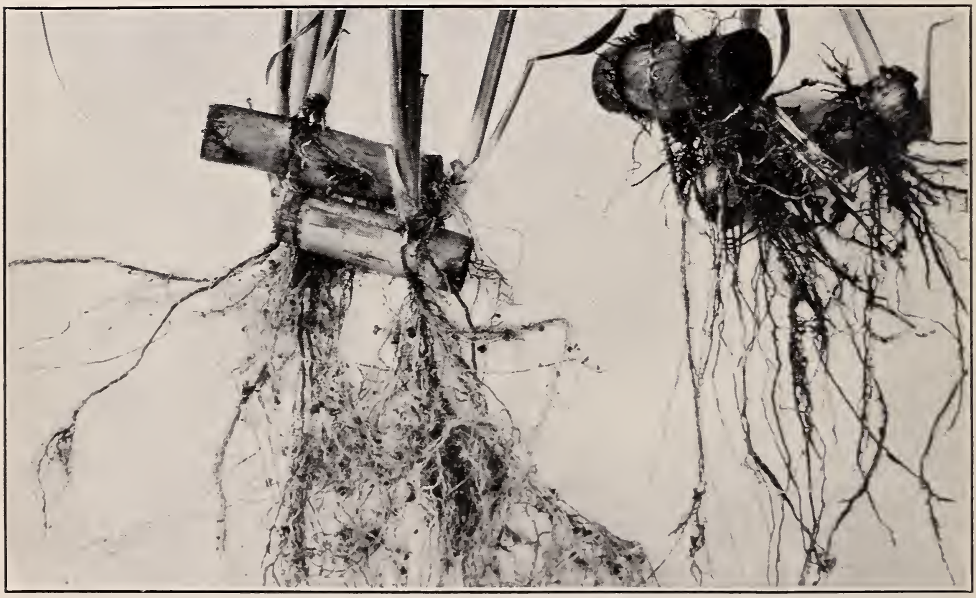

FIG. 2.—ROOTS OF SUGAR CANE. CONTROL AT LEFT; PLANT FROM SOIL INOCULATED WITH PYTHIUM ON RIGHT.

win to determine the most representative areas on which to carry on the investigation. These experiments were finally located at Haiku, at an elevation of 600 feet, and on the Haleakala substation, which is 1,800 feet above sea level.

EXPERIMENTS AT HAIKU.

A field at Lilikoi, owned by the Haiku Fruit & Packing Co., was selected as the most desirable and representative plat in the region for experimental purposes. As far as could be learned, this land was planted first to cane about 40 years ago, and after cropping for 12 or 15 years was allowed to revert to a forest of waiawi (*Psidium guayava pyriferum*) and kukui (*Aleurites moluccana*) trees. In 1912 it was cleared and planted to pineapples. One plant and two ratoon crops were taken off and the pineapple débris was plowed under in 1916. The ground was allowed to remain fallow for one year, and then it was planted to beans. These were a failure on account of attacks from aphids. One crop of corn was grown in 1918, but it was not much of a success. The land remained fallow from the fall of 1918 until August, 1919, when it was replowed and thoroughly disked in preparation for this experiment.

Forty-five plats, each one-tenth of an acre in size, were fertilized and planted on September 10, 1919. Pineapples, pigeon peas, and sugar cane have about the same cycle of productive growth and are admirably adapted to conditions on Maui. These crops are, therefore, considered best for rotation on the uplands. Soil samples were carefully taken to a depth of 2 feet from each plat, a large posthole auger being used for the purpose. About 150 pounds of soil were used for samples; a small portion was taken for chemical analysis and the rest for a pot-culture experiment. The same system of rotation and fertilization employed in the field was used in the pot-culture experiment. The pigeon peas in the pot-culture experiment were harvested on March 6, 1920. The following table gives the results of this experiment:

Comparative yields of pigeon peas grown in pot cultures.

Pot No.	Treatment.	Height of plant.	Total green weight.	Total air-dry weight.	Air-dry weight of stalks and leaves.	Air-dry weight of peas.
		Inches.	*Grams.*	*Grams.*	*Grams.*	*Grams.*
16	Check	31	67	36	25	11
17	Acid phosphate, 3.63 grams	26	81	49	31	18
18	Nitrogen mixture,[1] 3.28 grams	30	89	48	37	11
19	Sulphate of potash, 1.63 grams	37	72	45	24	21
20	Check	33	115	69	37	32
21	Acid phosphate, 3.63 grams; nitrogen mixture,[1] 3.28 grams	36	101	64	30	34

Comparative yields of pigeon peas grown in pot cultures—Continued.

Pot No.	Treatment.	Height of plant.	Total green weight.	Total air-dry weight.	Air-dry weight of plant and leaves.	Air-dry weight of peas.
		Inches.	*Grams.*	*Grams.*	*Grams.*	*Grams.*
22	Acid phosphate, 3.63 grams; sulphate of potash, 1.63 grams	32	90	54	25	29
23	Nitrogen mixture,[1] 3.28 grams; sulphate of potash, 1.63 grams	13	49	17.5	17.5	....
24	Check	33	80	37	31	6
25	Nitrogen mixture,[1] 3.28 grams; acid phosphate, 3.63 grams; sulphate of potash, 1.63 grams	37	93	54	36	18
26	Lime, 18.15 grams	41	92	60	33	27
27	Lime, 18.15 grams; manure, 245 grams	34	122	76	42	34
28	Check	41	68	43	28	15
29	Lime, 45.7 grams	35	78	48	30	18
30	Lime, 45.7 grams; manure, 245 grams	34	122	55	52	3

[1] A mixture of ammonium sulphate and sodium nitrate containing equal amounts of nitrogen in each form. This varies with the analysis but is approximately 45 per cent ammonium sulphate and 55 per cent sodium nitrate.

EXPERIMENTS AT HALEAKALA SUBSTATION.

Experiments have been begun to develop a fertility-rotation system for the higher elevation on the Haleakala slope. A three-year rotation with corn, beans, and potatoes was considered the most advisable for this region, and various cropping and fertilizer systems are being tested. The crops were planted in the latter part of March, 1920. On April 20 all the crops were showing a definite response to the fertilizer. This clearly indicates the lack of available plant food in these virgin soils.

TRIANGULAR FERTILIZER EXPERIMENTS WITH BANANAS.

This experiment was planned in February, 1919, by the former station chemist[3] and was conducted on 60 plats in the triangular system and 12 miscellaneous plats. The object was to determine the limit of plant foods necessary for maximum production and the proper combination of these plant foods. In March, 1919, the plats were planted to bananas, 2½, 4, and 5 months' old suckers being used for this purpose. After the planting, two applications of fertilizers were made, the amounts and combinations varying for the different plats. Some of the plats proved poorly drained, and it was necessary to open ditches through the lower end of the tract. A third application of fertilizers was made in October, 1919, and on January 14, 1920, the first cutting of bananas was made. Data have been kept as to the number and weight of the bunches, average number of hands per bunch, and bananas in the first hand. When compiled to the end of the fiscal year, the data revealed the influence of so many factors that the drawing of conclusions does not appear warranted. The data are withheld for further consideration and report.

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[3] Resigned Mar. 20, 1919.

PINEAPPLE-WILT INVESTIGATIONS.

The disease commonly known as pineapple wilt is doing considerable damage in the pineapple areas. The causal fungus (*Pythium* sp.) is found in the soil, and according to some pathologists is the same organism found on the roots of Lahaina cane. Many ideas and theories have been advanced for the cure of this disease, which is of primary concern to pineapple growers in Hawaii. An investigation was begun to find some toxic substances which would kill the fungus without seriously injuring the plant tissues. Plants properly fed are not so subject to wilt as those that are starved. Soluble plant food was given to the plants at the same time they received the fungicidal treatment. In half the plats the fungicide was sprayed on the leaves, and on the other half the solutions were poured on the soil near the base of the plants.

On November 10, 1919, 30 plats, each five-hundredths of an acre in size, were laid out in a plant-crop pineapple field at Kunia. Each plat contained 400 plants and was treated with combinations of fertilizers and fungicides, the latter including copper sulphate, Bordeaux mixture, mercuric chlorid, and iron sulphate. On November 13, 1919, those plants whose tops had been sprayed with bichlorid of mercury were as white as snow, but they gradually recovered and sent out leaves.

Experiments in a nutrient solution were tried out to ascertain the toxic limit of various antiseptics. (Pl. IV, fig. 1.) A small amount of copper sulphate, bichlorid of mercury, and calcium oxychlorid, or mixtures of these chemicals, had a stimulating effect on growth. Calcium oxychlorid seems to offer great promise because it does not injure the plants in concentrations of 1 to 1,000, and it is a strong fungicide.

TRIANGULAR EXPERIMENT WITH PINEAPPLES.

An experiment was begun in cooperation with F. G. Krauss at Haiku to determine the best proportions of nitrogen, phosphoric acid, and potash for pineapples on the upland soils of Haiku, Maui. The land was cleared in 1913. Since then it has been cropped to corn, interplanted with leguminous crops nearly every season until 1919. In 1915 commercial fertilizers were first applied in various forms and amounts. Late in the fall of 1919, 14 plats, each one-tenth of an acre in size, were laid out, fertilized according to a definite system, and planted with pineapple shoots in rows 4 feet apart. The plants were 16 inches apart in the rows. Samples of soils for chemical analyses were taken from all check plats. On February 24, 1920, the stand of young plants was very good. There was a small difference in favor of two plats, one of which received 60 pounds ammonium sulphate and sodium nitrate, and the other 20 pounds of sulphate of potash.

PRESERVATION OF ISLAND FOOD PRODUCTS.

The Hawaiian Islands must depend to a large extent on imports for their food products. The cost of transportation of such food products and the high prices paid for them have made living expenses in Hawaii extremely high. On account of this peculiar situation and the unsettled conditions at the present time, there has been a great number of inquiries and demands for information regarding the preservation of Hawaiian-grown perishable food products. Several methods of preserving home-grown products have been tried with success at this station. Among the fruits and vegetables preserved through drying are the following: Pineapples, bananas, papayas, mangoes, roselle, string beans, carrots, onions, beets, white turnips, kohl-rabi, cabbage, yellow turnips, and Irish potatoes.

Experiments have been conducted to test various methods of pickling avocados, papayas, mangoes, tomatoes, pineapples, bunch onions, cabbages, and carrots.

Jams and jellies have been made from mangoes, pineapples, bananas, Surinam cherries, papayas, pohas, and roselle.

PAPAIN INVESTIGATIONS.

The climate and soils of the Hawaiian Islands are ideal for the production of papayas. This crop is not exported as fresh fruit largely because it would be necessary to pick the fruit when green and artificially ripen it. As a result, the flavor would be very poor compared with fruit which ripens on the trees. Enough of the fruit could be grown in the back yards and waste places about Honolulu to make possible a large industry. The station conducted an experiment to discover the best methods of extraction and purification of papain. Papain is sold on the world markets according to locality of origin. Ceylon supplies most of the papain sold, but it is poor in quality. The Philippine Islands and Mexico produce only a small output, which is superior to that produced in Ceylon.

The chemistry department has extracted papain from 90 or 100 papaya trees and dried it by various methods. Sun drying is just as efficient as oven drying, and in most parts of the islands is preferred to oven drying, except in the heavy rain areas.

The proteolytic activity is one of the essential factors in papain. Methods for determining this activity are being worked out by this station for comparison with methods developed in the Philippines, United States, and Ceylon. Present data on hand are not sufficient to make a definite statement regarding the best method of determining the proteolytic activity in papain.

RICE SURVEY OF THE HAWAIIAN ISLANDS.

Rice culture on the Hawaiian Islands is handled mostly by the Chinese. The areas devoted to rice growing are decreasing because the old Chinese are dying off and the immigration laws forbid the replacement of these laborers. This year the situation was made more acute than usual by the high prices paid for labor on sugarcane plantations. In 1907 F. G. Krauss reported that there were over 10,000 acres in rice in Hawaii. The total area in rice on these islands at present is about 6,200 acres. Most of the old rice land is now in cane. The present trend is to decrease the area planted to rice and to use it for sugar cane.

Most of the rice land is still handled by the methods used for hundreds of years in the Orient. The land is first plowed with water buffalo; water is then allowed to run in and the soil is harrowed or mulched wet. The seed is first grown in seed beds, and when about 6 inches high it is transplanted to the wet, prepared seed bed. The land is weeded by hand when the plants have been out about a month. After the land is weeded it is allowed to dry for a few days and then it is fertilized. Water is then turned back onto the field. The length of the growing period in these islands depends mostly upon the variety and the season. Japan rice matures in 100 days, while the Hawaiian standard or Chinese rices require 120 or 130 days to mature. All the rice grown is consumed locally. The wholesale price from January to June, 1920, was approximately $12 per 100 pounds of milled rice.

REPORT OF THE DIVISION OF PLANT PATHOLOGY.

By C. W. Carpenter.

During the fiscal year 1920 studies of diseases affecting local crops were continued, and special attention was given to the new root-rot project, which was mentioned in the last annual report of the division. Miscellaneous specimens of diseased plants submitted for diagnosis and advice were examined and recommendations for control were made.

On the island of Molokai an experiment to demonstrate the practicability of controlling the taro rot disease, inaugurated as a part of the World War Food Campaign, was completed. On the island of Oahu the cooperative spraying experiments for the control of the banana freckle disease were continued under the writer's supervision. The regular work of the division was terminated on November 15, 1919, by the pathologist's resignation. He satisfactorily closed the major projects and continued his connection with the station as consulting collaborator along plant disease lines.

A bulletin entitled "Potato Diseases in Hawaii and Their Control,"[4] was published during the year. This publication describes important diseases and insect pests which are detrimental to the potato industry and such control measures as seem adapted to the situation. This bulletin will probably be especially useful to the small farmer of Hawaii to whom potato failures have been a continual source of discouragement. These failures are due to the ravages of fungus diseases and insect pests. Some important diseases which do not occur in the islands are also described so that their introduction may be better guarded against.

The results of a survey of some of the local root-rot diseases were published as a press bulletin[5] with the title "Preliminary Report on Root Rot in Hawaii (Lahaina Cane Deterioration, Pineapple Wilt, Taro Rot, Rice Root Rot, Banana Root Rot)."

ROOT-ROT DISEASES.

Diseases of plants in which root failure is the most striking feature, affect a number of the important crops of Hawaii, including cane, pineapples, bananas, taro, and rice. As a result of root failure and inability of the plant to maintain an adequate root system, the plants show a checked growth followed by more or less drying, yellowing, and wilting of the foliage. In many cases the plant either barely maintains existence, or dies. This type of disease is well illustrated by the root rot of cane called "Lahaina disease," or Lahaina variety deterioration, and by pineapple wilt disease, taro rot, and the like. For many years similar diseases of cane and pineapples have been a source of grave concern to growers in practically every country producing these crops. The cause has never been satisfactorily demonstrated. It was observed in all the root-rot diseases mentioned that a fungus of the Pythium type is associated with lesions on the roots. (Pl. V, figs. 1 and 2.) The theoretical working hypothesis advanced was that several of the important root-rot diseases were of fungus origin; and the results of preliminary experiments supported this view. Under this hypothesis the cause is a fungus of the Pythium type which is active under suitable soil conditions. The diseases are largely a "damping off" of the roots. The problem is outlined and the preliminary results recorded in Press Bulletin

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[4] Hawaii Sta. Bul. 45 (1920).

[5] Hawaii Sta. Press Bul. 54 (1919).

No. 54. Inoculation experiments that have been completed with Lahaina cane strongly support the theory that the root-rot disease of cane under discussion is caused by a fungus of the Pythium type. (Pl. IV, fig. 2.) Soil conditions likewise are believed to be an important if not a determining factor in the occurrence of the disease. (Pl. VI, figs. 1 and 2.) Further studies may reveal other parasitic root organisms of interest in relation to this type of disease.

TARO-ROT CONTROL EXPERIMENT.

Although poi, the popular Hawaiian food, is generally made from taro, wheat flour is often substituted where it is more convenient and cheaper to do so. As a part of the wheat-conservation campaign carried on during the war, means were sought to encourage the growing of taro. This neglected industry has waned as the result of the lack of application of the best agricultural practices and on account of the prevalence of the root-rot disease. The taro disease destroyed most of the crop on the island of Molokai at a time when the limited supply of wheat worked a hardship on the people of some of the more remote valleys. To control this disease a demonstration experiment was attempted in the valley of Halawa in cooperation with the trustees of the Bernice P. Bishop estate. This experiment was necessarily far from being under direct supervision and was carried on under some difficulties; but it was successful in showing the value of drying out and plowing up the patches in contrast with continuous planting to taro without drying out the patches between crops. Applications of lime at the rate of 2 tons per acre, and coral sand at the rate of 4 tons per acre were of some benefit. Definite conclusions could not be drawn from the final yield of the various plats as to the value of fertilizer, lime, and coral sand over no treatment. It is significant, however, that the whole patch yielded at the rate of 14 tons of taro per acre apparently as the result of having been plowed, harrowed, and dried out. Other experiments made by growers of taro in Halawa gave strong indications that taro rot could be practically controlled by drying and plowing the patches and by applying either lime or coral sand some time before they are replanted to taro.

A patch 18 by 66 feet, which had yielded no marketable taro for three years, was disinfected with copper sulphate in the irrigation water before the crop was planted, and also twice while the crop was growing. The huli were selected and disinfected in copper sulphate. Fifteen sacks of taro, only 5 per cent of which were rotted, was the reported yield of this patch.

At the close of the work in Halawa there was a considerably greater area in taro than there had been at the beginning, several of the abandoned patches having been reclaimed.

BANANA FRECKLE DISEASE (PHOMA MUSÆ).

The methods devised for the control of this disease and outlined in the 1919 report were followed during the year. Sanitation, pruning, and spraying with Bordeaux mixture have very materially reduced the damage to plants and fruits. For various reasons the spraying operations were not as thorough and frequent as it was desired they should be, and it has not been demonstrated that they are a practicable means of control. It was generally noted that neglected fields and most plants, which did not receive careful attention as to fertilizing and irrigation, showed much less leaf and fruit spotting by *Phoma musæ* than plants that were in the height of vegetative vigor in the cared-for fields. This suggests that the use of nitrogenous fertilizers might be a factor predisposing to disease. However, in some other plant diseases the most vigorous appearing plants are seemingly preferred for attack.

REPORT OF THE HAIKU SUBSTATION.

By F. G. Krauss.

The experimental phases of the work at the Haiku substation have been necessitated by local demand for information, which could not be obtained other than by direct experiment. This experimental work has been financed from the regular experiment station funds and data of such practical importance have been secured as to justify the publication of the results. The Haiku substation consists of two branches, the Haiku substation proper, which was the original farm referred to in the report for 1916[6] as the "upper demonstration farm," and the Patterson demonstration farm which was referred to in the same report[7] as the "lower demonstration farm." This second farm practically adjoins the first farm, but for purposes of record the name "Patterson demonstration farm" is used to distinguish it from the land of the Haiku substation proper, now referred to as the Haiku substation.

CLIMATIC CONDITIONS.

While the temperature of Hawaii is remarkably uniform, the rainfall over a wide area of the agricultural lands is extremely erratic, both in its seasonal distribution and yearly totals. The accompanying graphs (fig. 2) cover the monthly rainfall for the 20-year period from 1900 to 1919, inclusive. The average annual rainfall for the

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[6] Hawaii Sta. Rpt. 1916, p. 35.
[7] Hawaii Sta. Rpt. 1916, p. 33.

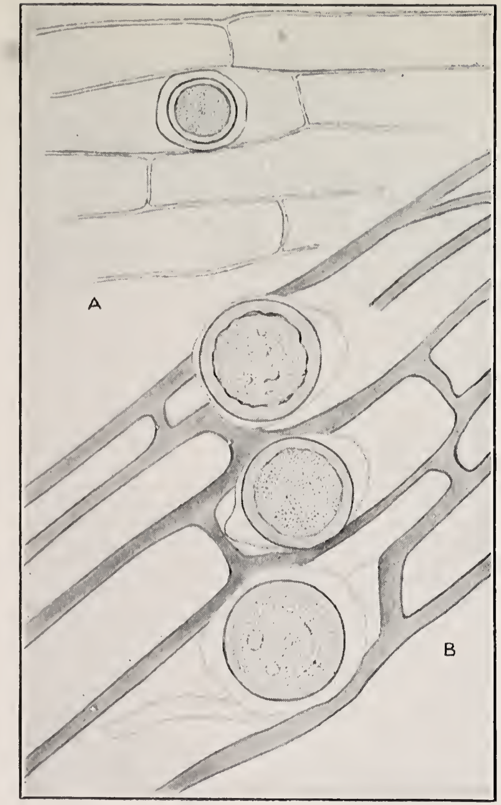

FIG. I.—ROOT ROT FUNGUS.

A, Resting spore of pythium-like fungus in cell of Lahaina cane; *B*, resting spores of similar fungus in cells of banana root. (× about 450.)

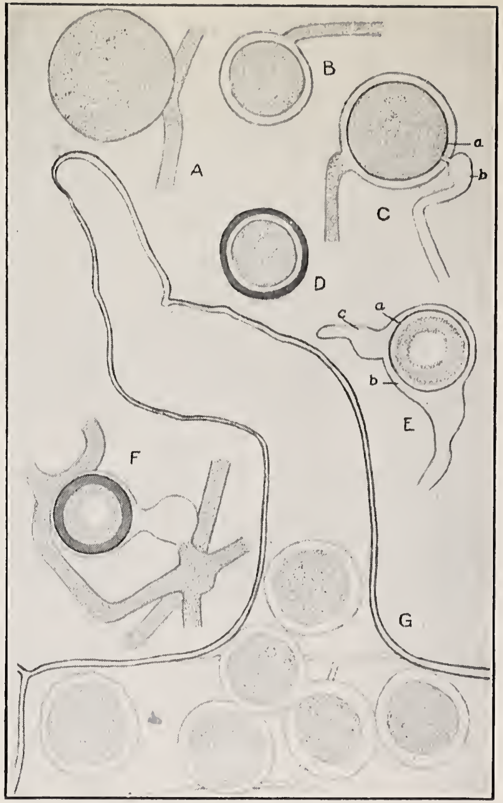

FIG. 2.—ROOT ROT FUNGUS.

A–D, Pythium from rice roots in cultures; *E*, pythium from culture of Lahaina cane. *F*, same as *E* after fertilization, oospore with heavy wall; *G*, root hair of Lahaina cane showing several spores. (× about 450.)

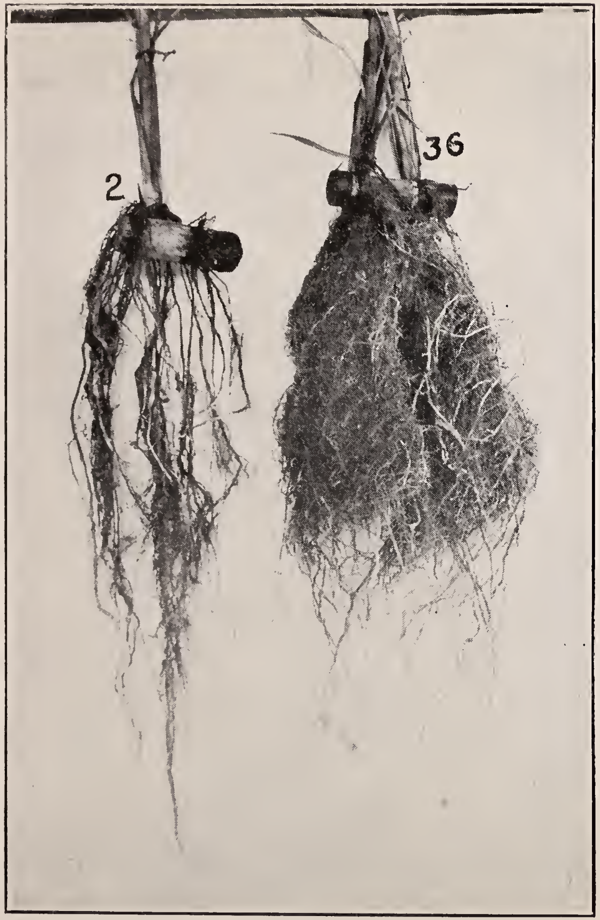

FIG. I.—COMPARATIVE ROOT SYSTEMS OF THREE-MONTHS OLD LAHAINA CANE (2) IN SICK WAIPIO SOIL; (36) IN SAME SOIL DISINFECTED WITH FORMALDEHYDE.

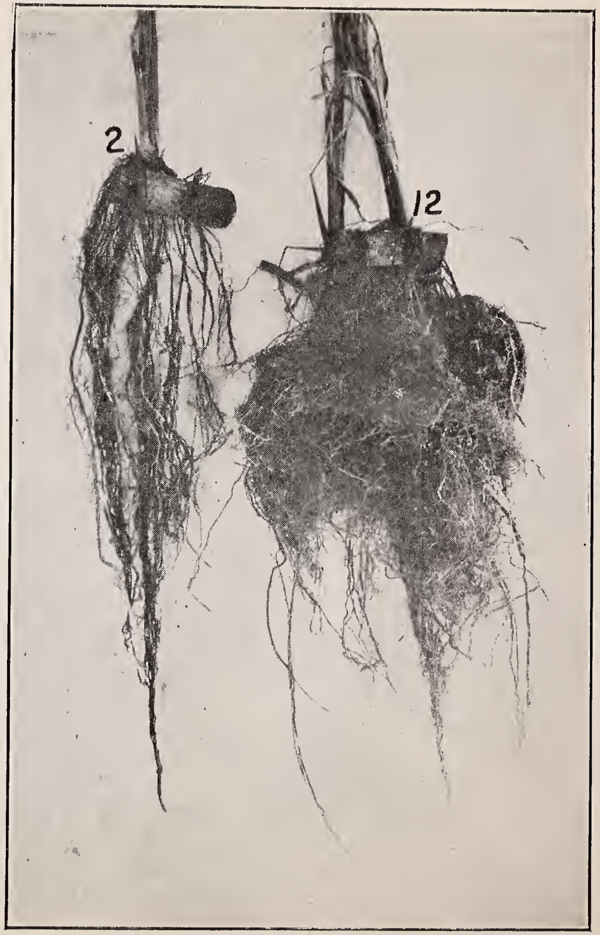

FIG. 2.—COMPARATIVE ROOT SYSTEMS OF THREE-MONTHS OLD LAHAINA CANE (2) IN SICK WAIPIO SOIL; (12) IN SAME SOIL STEAM STERILIZED.

district is about 75 inches, yet the extremes of less than 50 inches and more than 100 inches are not uncommon.

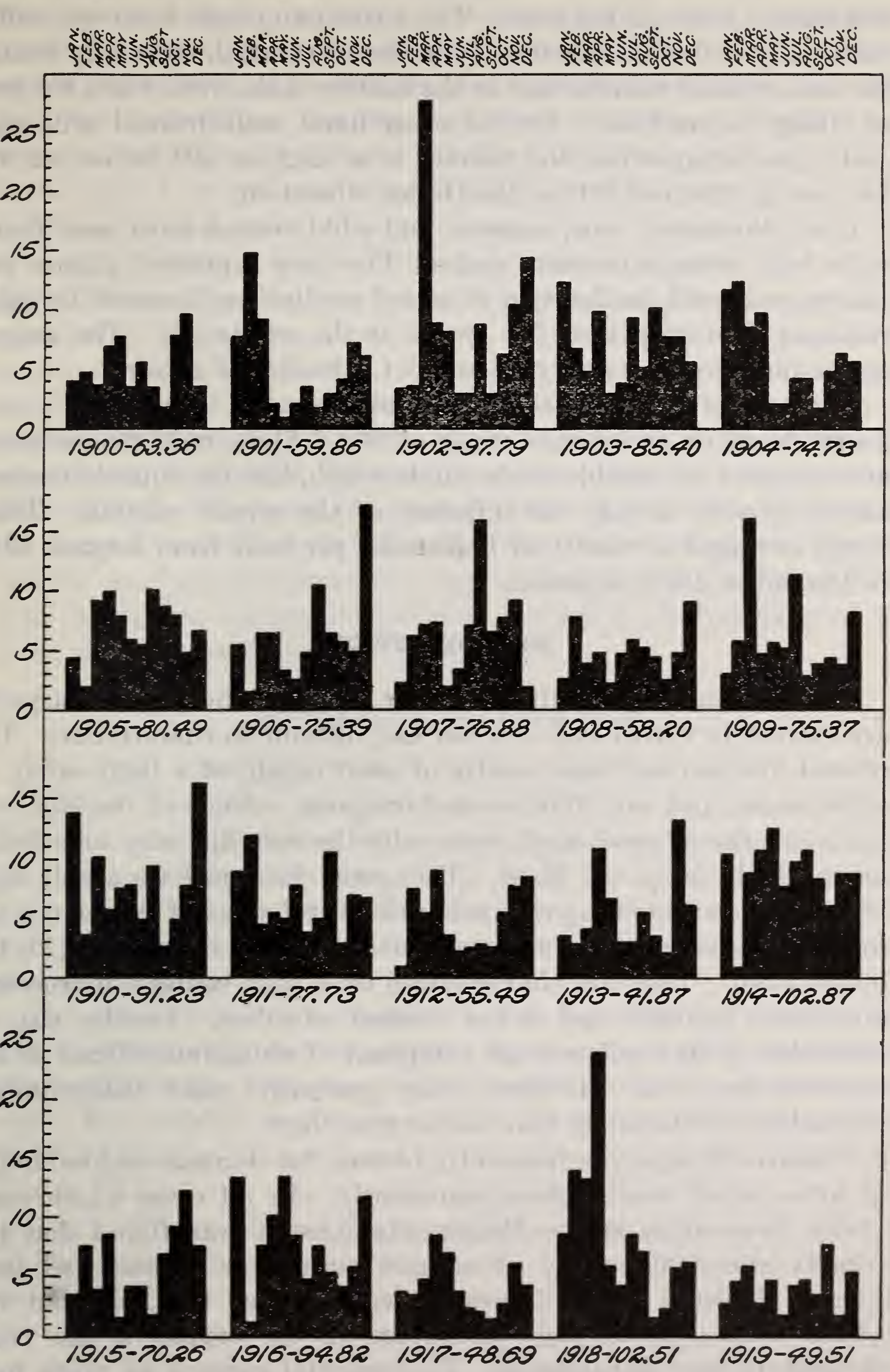

Fig. 2.—Monthly rainfall, 1900–1919, at Haiku, Maui. Compiled from records of Mrs. L. B. Atwater and the Haiku substation by D. Krauss.

Short-season field crops, especially beans, Indian corn, and potatoes, have been found to adapt themselves to a fairly wide range of rainfall when the land is well drained, maximum yields being confined to from 50 to 75 inches of rainfall when it is quite evenly distributed through the year. The latter two crops, however, suffer materially if there is less than 50 inches of rainfall, especially during the hot summer months and in the heavier soils, even when the best of tillage is practiced. On the other hand, well-drained soils may yield good crops when the rainfall is as high as 100 inches, as was the case in 1914 and 1918 at the Haiku substation.

Uba (Japanese) cane, cassava, and edible canna have been found to be very drough-resistant crops. The deep taprooted pigeon pea has proved itself, on the basis of actual production, the most drought-resistant field crop thus far grown at the substation. The annual leguminous crops are very tolerant of extremes of rainfall.

The temperature ranges from a minimum of 55 to 85° F. on a yearly basis, or an extreme range of 30°. These mild temperatures are tempered by equable trade winds which, like the equable temperatures, greatly modify the influence of the erratic rainfall. These winds averaged a velocity of 10.31 miles per hour from August, 1916, to December, 1919, inclusive.

SOIL CONDITIONS.

The soil conditions, both from their chemical and physical aspects, are extremely varied and complex and difficult to characterize. The coastal lowland soils are usually of good depth, of a light sandy or silty nature, and very fertile when irrigated. Much of the high uplands are also of good depth, especially the very fine silty soils found on the Kula lands at Maui. The great intermediate arable land bodies representing the principal agricultural areas of the islands are soils of a heavier nature and are usually shallow compared with the others cited. They are characterized by a high content of iron and aluminum hydrates and a low content of silica. Usually the so-called heavy clay soils are not composed of aluminum silicate as are the true clay soils. However, they generally scour tillage-implements less satisfactorily than do the true clays.

Climatic changes are frequently blamed for decrease in production of areas which once yielded abundantly. In all cases which came under observation at the Haiku substation it was found that the usually abundant supply of organic matter, or humus, had been greatly depleted through poor management of the land, but the yields were doubled and quadrupled in the course of six years through proper management. The essential element of plant food is rapidly dissipated during dry, windy seasons, especially in locations where too bare fallow, or dry, open field, or intertillage, is practiced. The mineral part of plant food to be available to crops must in large part be in soluble form. In such condition, it is, of course, readily leached out of porous soils, or eroded from more compact soils during periods of heavy rainfall. Good farm management, especially in the Tropics, requires that the soil be kept constantly at work to prevent its good qualities from being lost. For this reason, cropping systems have been devised necessitating continuous cropping and rational rotations, including at least twice in three years a heavy cover crop which is preferably a legume. This legume is turned under as a green-manuring crop to replenish stores of organic matter. At the Haiku substation in a 5-acre field experiment, 70 tons, the product of three heavy leguminous crops covering a period of three years, were turned under before it was possible to notice any beneficial results. Then the soil began to yield as it had never yielded before, producing first 56 bushels of corn, then 64 bushels, and finally 100 bushels, which were record crops, against the average of 37 bushels obtained from the adjacent section of untreated land. However, the treated lands later became deficient in the mineral constituent phosphorus. When this element was supplied as acid- or super-phosphate, or reverted phosphate to the soils already rich in organic matter, immediately preceding the planting of the crop, the land produced abundantly.

PINEAPPLE EXPERIMENTS.

Pineapple investigations have had an important place in the work at Haiku. The remarkable development of the pineapple industry in Hawaii has extended the planted areas to new and untried locations, and has necessitated replanting large areas a second and even a third time. This is bringing in its train new problems, the solution of which will in large measure determine the future growth of this important industry.

The results of the experiments herein reported are based on the first or plant crop harvested from the extensive field experiments conducted at the Patterson demonstration farm. In these experiments less striking results were had from the use of fertilizers than were obtained in former years at the main farm of the Haiku substation, where the seasons were generally characterized by heavy rainfall. The yields and the appearance of the crops on the Patterson fields during the past two dry years have, on the whole, been remarkably good, regardless of treatment. Past experiences on the Patterson demonstration farm, present experiments, and observations covering the whole of the Haiku district show that dry-weather conditions, such as prevailed in 1917 and in 1919, and up to June 30, 1920, are extremely favorable to the growth and development of the pineapple plant and fruit; and the wet seasons of 1914, 1915, 1916, and part of 1918, were very destructive to the pineapple crops, especially on the shallow and poorly drained soil areas. The fact is emphasized that on soils which are apparently deficient in phosphates for other crops, no greatly increased yields or profitable returns can be expected from the use of mineral fertilizers on good, basic, pineapple soils provided good plants are used and adequate tillage is practiced. In no instance does the gain exceed 8 per cent when the phosphates are broadcasted between the rows at the rate of 1,000 pounds per acre, as, for example, in the case of finely ground bone meal. (See table headed "Results of Applying Phosphate Fertilizer to Pineapples," plat 6, p. 47.) This is also true in the case where reverted phosphate was used. (Same table, plat 4.) Since 5 per cent at least should be allowed for experimental error, it can readily be seen that these fertilizers exerted an influence too small to be given much weight. In the application of raw phosphate rock, broadcasted at the rate of 2,000 pounds per acre, there appeared to be a slightly decreased yield, but this is well within the range of experimental error.

When the phosphates were applied in the furrows immediately beneath the plants in the single rows, the difference in yields between the fertilized and unfertilized plats was very slight; this made it quite certain that no additional influence was exerted by these comparatively large amounts of fertilizing materials applied at a point where the roots were most certain to come in contact with them.

In the double-row planting (see table headed "Results of Applying Phosphate Fertilizer to Pineapples," plats 20 to 26, inclusive) there appears to be rather a wide variation, the bone meal and one of the reverted phosphate plats apparently exerting a rather detrimental influence. This must be due to soil variations rather than to the influence of the fertilizer materials and the results should, therefore, be ignored for the present. The general conclusions are that in these experiments the phosphatic fertilizers exerted influences too slight to make any definite deductions possible. In all of the experiments, except where otherwise stated, select pineapple slips were used.

FERTILIZER EXPERIMENTS.

A number of fertilizer experiments were conducted on field I of the Patterson demonstration farm. The crop was planted in August and September, 1918, and harvested from June to December, 1919. (See record of monthly precipitation, p. 41.)

LIMING EXPERIMENTS.

The object of these experiments was to learn whether the Veitch method of determining the lime requirements of soils for crops is applicable to pineapples, and if so, what form, amount, and method of application is best. Liming had evidently proved beneficial in preliminary experiments conducted in field culture at the Haiku substation, and in pot cultures at the experiment station at Honolulu. Land under test was cleared of a medium growth of guava in 1912 and partly plowed. It was then left fallow until 1915 when it was brought into a good condition of tilth, a rank growth of Hilo grass being turned under as far as possible and the remainder burned. New Era 100-Day Yellow Dent corn, intercropped with jack beans (*Canavalia ensiformis*) as index crops, was planted in the spring of 1915. Corn grew poorly, yielding only 21 bushels per acre without fertilizer. The jack beans made a fine growth, yielding 1,100 pounds of seed per acre and 21 tons of green matter which was turned under as manure. Corn, with cowpeas, velvet beans, and sunn hemp (*Crotalaria juncea*) was grown successively until the early summer of 1918. Approximately 60 tons of green matter had been turned under by this time, and approximately 1½ tons of corn and leguminous seeds were taken off the land between 1915 and 1918, preceding the planting of the pineapple crops entering into these experiments. The general growth of the index crops showed the soil to be fairly satisfactorily uniform.

Preparatory to planting the pineapple crops, the land received three plowings, each 10 inches deep, six double diskings, and three culti-packings at approximately 6-week intervals for each plowing and associated disking. The total cost of this tillage was approximately $55 per acre.

The object of liming experiment No. 1 was to determine the value of burned lime when disked into the soil immediately before planting pineapples, and when applied 30 days before planting. Burned lime at the rate of 3,000 pounds per acre, which was produced from the ordinary " coral beach sand " burned at the kilns at Paia, Maui, was broadcasted and double disked into the first 4 inches of the surface soil. The soil was in good tilth and moderately moist.

Plantings were made in both the single and double row method. In the single-row method, the rows were spaced 4 feet apart and the plants, at an average of 15.7 inches apart in the row. In the double-row method the two rows forming the double row were spaced 2½ feet apart, and these double rows 5 feet apart, the plants being spaced in the double rows as in the single rows. By these methods approximately 8,320 and 8,880 plants, respectively, were set per acre. All calculations are made on these bases.

In experiment No. 1 burned lime was applied immediately before planting in comparison with burned lime applied 30 days before planting, and the results are given in the table following.

Relative effect of applying burned lime immediately before planting and 30 days prior to planting on single and double rows planted to pineapple shoots.

Plat No.	Number of plants per plat.	Treatment per acre.	Average weight of fruit.	Calculated yield per acre.
			Pounds.	*Tons.*
1	1,181	3,000 pounds burned lime (applied immediately before planting; single rows)	3.89	16.182
2	671	3,000 pounds burned lime (applied 30 days prior to planting; single rows)	4.37	18.179
3	868	No treatment (single rows)	4.06	16.889
4	163	Same treatment as plat 2 (double rows)	4.17	18.515
5	49	Same treatment as plat 1 (double rows)	3.26	14.474
6	503	No treatment (double rows)	3.82	16.961

The results of these experiments seem to indicate that the application of burned lime to the soil immediately before planting pineapples may exert a detrimental influence on the resultant crop, as was the case in plat 5. It will be noted that the yield apparently depreciated 4,973 pounds, or about 12 per cent; and that no influence can be noticed in plat 1. On the other hand, when the same amounts of burned lime were applied 30 days before planting, a beneficial result followed, amounting to a gain of 2,579 pounds in plat 2, or 7½ per cent, and a gain of 3,108 pounds in plat 4, or 9 per cent. These gains are manifestly substantially beyond the range of experimental error.

In experiment No. 2, liming with burned lime, hydrated lime, ground coral rock, and coral beach sand was tried. In this experiment all associated conditions prevailed as in experiment No. 1.

The object of liming experiment No. 2 was to determine the comparative value of different forms of lime when broadcasted at time of planting and when applied in like amounts in furrows just beneath the plants. In the lime broadcasted experiments the lime was scattered immediately after the plants were set, and quickly disked in. When applied in the furrows, it was also disked in to give more even distribution and to mix well with the soil, and planting followed at once. Less than a day elapsed between applying the materials and planting. The ground limestone came from Waianae, on the island of Oahu, and the other materials from Paia, on the island of Maui.

The layout of experiment No. 2 was the same as in experiment No. 1, four forms of lime applied in two different amounts being used—in furrows and broadcasted and in single and double rows. The results of this experiment are given in the table following.

Results of liming areas planted to pineapple slips in experiment No. 2.

Plat No.	Number of plants per plat.	Fertilizer treatment per acre.	Average weight of fruits.	Calculated yield per acre.
			Pounds.	*Tons.*
[1] 1	779	2,240 pounds burned lime	4.95	10.592
2	730	4,480 pounds burned lime	5.11	21.257
3	702	3,000 pounds hydrated lime	5.15	21.424
4	715	6,000 pounds hydrated lime	5.08	21.133
5	746	4,000 pounds ground limestone	4.86	20.217
6	696	8,000 pounds ground limestone	4.86	20.217
7	732	6,000 pounds beach sand	4.79	19.926
8	718	12,000 pounds beach sand	4.83	20.093
9	732	5,000 pounds, all above forms of lime mixed together in equal proportions	4.92	20.467
10	1,013	No treatment (check)	4.42	18.387
[2] 11	272	2,240 pounds burned lime	4.89	20.342
12	268	4,480 pounds burned lime	4.53	18.845
13	264	3,000 pounds hydrated lime	4.76	19.801
14	273	6,000 pounds hydrated lime	4.55	18.928
15	259	4,000 pounds ground limestone	4.78	19.885
16	272	8,000 pounds ground limestone	4.53	18.845
17	272	6,000 pounds coral beach sand	4.94	20.550
18	291	12,000 pounds coral beach sand	4.77	19.843
19	(3)	No treatment (check)	4.77	19.843
[4] 20	488	2,240 pounds burned lime	4.52	20.064
21	533	4,480 pounds burned lime	4.36	19.308
22	276	No treatment (check)	4.31	19.136
23	493	3,000 pounds hydrated lime	4.57	20.290
24	588	6,000 pounds hydrated lime	3.79	16.847
25	266	No treatment (check)	3.85	17.094
26	543	6,000 pounds coral beach sand	3.68	16.339
27	564	13,000 pounds coral beach sand	3.58	15.895
28	283	No treatment (check)	3.37	14.963

[1] Plats 1 to 10, inclusive, single rows; broadcasted immediately after plowing.
[2] Plats 11 to 19, inclusive, single rows; applied in furrows.
[3] Four plats.
[4] Plats 20 to 28, inclusive, double rows; applied in furrows.

In plats 1 to 9, inclusive, in this second series of liming experiments, rather substantial increased yields resulted apparently from the application of all the materials which were broadcasted immediately after planting. The use of 3,000 pounds of hydrated lime increased the yield of pineapples by about 6,068 pounds per acre, while 6,000 pounds of hydrated lime increased the yields of pineapples by about 4,735 pounds per acre over the plats serving as checks. This is equivalent to increases of approximately 16 and 15 per cent, respectively. If 5 per cent is allowed for experimental error, the average increase is 10 per cent as a result of application of 1½ tons of hydrated lime, which is apparently the more favorable quantity to apply. Burned lime gave a slightly smaller increase than hydrated lime, while the ground limestone and coral sand were almost without effect. It is likely that the margin of profit remaining after the heavy costs of transportation are met on these materials, even though this initial cost is small, would not warrant their use, except in special cases. In nearly every instance where the materials were applied in furrows immediately below the plant, the gains were either negligible or negative.

In all instances where the increase or decrease is within 5 per cent, the results should be considered within experimental error. A possible explanation of the better results obtained from broadcasting the materials and disking in between the rows than from applying large quantities of the same materials in furrows directly under the plants, as in plats 14 to 27, inclusive, is that in the former case the young roots did not immediately but gradually come into contact with the more diluted materials. In the latter case, the roots quickly came into contact with the more concentrated materials. In any event, it would seem that both hydrated and burned lime, as well as ground limestone and sand, may safely be applied in relatively large quantities, if they are rightly handled. This is in conformity with the unpublished results obtained by M. O. Johnson, formerly chemist of the experiment station, with similar soils when used in pot cultures. On the other hand, the general view of a number of practical growers is that lime in all forms and methods is injurious.

It should be stated that all the plats involved in these liming experiments, including checks, showed up well throughout the growing season, no yellowing or collapsing appearing. At the time of this writing (June 30, 1920) the plants are standing up well in the first ratoon crop. At the Haiku substation in 1918 first ratoon plants which collapsed because of the excessive rains that fell during the first half of the year were revived and bore 3-pound fruits after 2,000 pounds of burned lime per acre had been disked into the soil. Untreated plants either died or produced fruits averaging less than 2 pounds. On these lands the Veitch test showed a lime requirement of 2,600 pounds per acre. Other tests with burned lime have also shown beneficial results immediately following wet years. However, it can not be stated at this time whether this was due to its tendency to flocculate and make lighter the heavier soils, to correct the acidity, or to overcome the lime deficiency. M. O. Johnson, formerly chemist of the station, has stated that he believes that certain forms of the wilt or the characteristic slow collapse of the plants may be due to the high acidity and that lime neutralizes the excessive acidity.

PHOSPHATE FERTILIZER EXPERIMENTS.

In the phosphate fertilizer experiments previous cropping and preparation of land was practiced as in the liming experiment just discussed. The object of these phosphate experiments was to determine the relative value of phosphorus when applied to pineapples in the form of (1) acid phosphate (superphosphate), (2) reverted phosphate, (3) bone meal (finely ground), and (4) raw phosphate rock (very finely ground). All these forms were each applied in two quantities, that is, at the rate of 500 and 1,000 pounds, respectively, for the first three materials and at the rate of 1,000 and 2,000 pounds for the raw phosphate rock. Likewise, each of the materials was applied by broadcasting between the rows and disking in, and in the furrow immediately beneath the plants. In the broadcasted lots the applications were made immediately after the plants were set and then they were disked in. Applications in the furrows were made immediately before planting.

The general layout of this series of experiments was the same as in the liming experiments. The results obtained are shown in the following table:

Results of applying phosphate fertilizer to pineapples.

Plat No.	Number of plants per plat.	Fertilizer treatment per acre.	Average weight of fruits.	Calculated yield per acre.
			Pounds.	*Tons.*
[1] 1	373	500 pounds superphosphates	4.10	17.056
2	455	1,000 pounds superphosphates	4.10	17.056
3	514	500 pounds reverted phosphate	4.16	17.305
4	368	1,000 pounds reverted phosphate	4.29	17.846
5	397	500 pounds bone meal	4.08	16.973
6	315	1,000 pounds bone meal	4.33	18.013
7	296	1,000 rock phosphate	4.15	17.264
8	214	2,000 pounds rock phosphate	3.33	13.854
9	392	1,000 pounds all forms of phosphate	4.33	18.013
10	319	No treatment (check)	4.00	16.640
[2] 11	170	1,000 pounds superphosphate	3.99	16.598
12	236	500 pounds superphosphate	4.11	17.097
13	209	1,000 pounds reverted phosphate	4.13	17.181
14	229	500 pounds reverted phosphate	4.02	16.723
15	199	1,000 pounds bone meal	4.12	17.139
16	195	500 pounds bone meal	4.35	18.094
17	218	2,000 pounds rock phosphate	4.38	18.221
18	185	1,000 pounds rock phosphate	4.46	18.553
19	401	No treatment (check)	4.35	18.196
[3] 20	289	1,500 pounds superphosphate	4.13	18.337
21	286	750 pounds superphosphate	4.01	17.804
22	289	1,500 pounds reverted phosphate	4.10	18.204
23	398	750 pounds reverted phosphate	2.80	12.432
24	402	1,500 pounds bone meal	2.76	12.254
25	427	750 pounds bone meal	2.71	12.032
26	503	No treatment (check)	3.19	14.163

[1] Plats 1 to 10, inclusive, single rows; broadcasted immediately after planting and cultivated in.

[2] Plats 11 to 19, inclusive, single rows; phosphates applied in furrows to compare with broadcasting between rows.

[3] Plats 20 to 26, inclusive, double rows; phosphates applied in furrows to compare with broadcasting between rows.

EFFECT OF USING PLANT RESIDUES AND GREEN-MANURING CROPS.

Select pineapple crowns or tops were used in the experiments on fertilizing with plant residues and green-manuring crops, and the previous cropping and basic treatment of land, other than the exceptions noted, was the same as for the liming and phosphate experiments.

The object of these experiments was to determine the relative productivity of pineapples on (1) virgin soil; (2) soil previously cropped to pineapples and a rotation of corn, intercropped with leguminous crops, all the plant residue being removed, including the pineapple plant residue, covering the period 1915–1918; (3) soils previously cropped as in (2), but all plant residue turned under; and (4) to determine the relative value, if any, of underlaying the pineapple rows with (a) corncobs; (b) cornstalks; (c) green cowpea vines, (d) green jack bean vines, (e) green pigeon pea vines, and (f) green weeds and grass.

Approximately 5 tons of the dry corncobs and corn stover were used per acre. Approximately 20 tons of green herbage were used per acre. The volume, as well as actual dry matter in each case, was approximately equal. Deep furrows were plowed and the materials were laid in the furrow. Six or eight inches of soil was then plowed over the material, firmed, and let lie four weeks before the pineapples were planted directly over the treated rows.

The pineapple residue turned under in this experiment weighed approximately 30 tons per acre, and the other various crop residues approximately 20 tons per acre, making a total of approximately 50 tons of vegetable matter turned under per acre. This was plowed under as deeply as possible, and approximately 100 days intervened between the last material plowed under and the time of planting of the pineapples. The following table gives the results of this experiment:

Effect of placing various forms of vegetable matter beneath pineapple plants.

Plat No.	Number of plants per plat.	Treatment of plat.	Average weight of fruits.	Calculated yield per acre.
			Pounds.	*Tons.*
1	2,984	Single row check plat. No treatment	3.64	15.142
2	251	Underlain by corncobs	3.95	16.432
3	122	No treatment (check)	3.99	16.598
4	267	Underlain by cornstalks	4.09	17.014
5	136	No treatment (check)	3.89	16.184
6	281	Underlain by green cowpea vines	4.20	17.472
7	230	No treatment (check)	3.38	14.060
8	287	Underlain by green jack bean vines	4.61	19.177
9	216	No treatment (check)	3.06	12.729
10	261	Underlain by green pigeon pea vines	4.97	20.679
11	135	No treatment (check)	4.40	18.304
12	185	Underlain by green weeds and grass	4.49	18.678
13	189	No treatment (check)	4.13	17.181
14	2,784	No treatment. Double row check plat [1]	3.46	15.362
15	2,934	Previously planted to pineapples, followed by a rotation of corn intercropped with legumes. All plant residue removed. None turned under	3.06	12.749
16	2,107	Previously planted to pineapples, followed by a rotation of corn intercropped with leguminous crop residues other than pineapple débris turned under	3.33	13.853
17	1,438	Previously planted to pineapples, followed by a rotation of crops. All crop residues turned under	3.55	14.768

[1] 8,880 plants per acre.

In this series of experiments the application of dry vegetable matter (plats 2 and 4) apparently exerted very little influence, the little gain shown being within experimental error. This was probably due to the very dry weather prevailing during the period of the experiment. At the Haiku substation and elsewhere, similar materials and also coarse rank stable manure have invariably shown beneficial results, especially during the wet seasons. On the other hand, where the plant rows were underlain by green vegetable matter, as in plats 6, 8, 10, 12, but more especially in plat 10, in which green pigeon pea vines were used, there appears to have been a substantial increase in the weight of fruit produced. It is possible that in a dry season the succulent, green organic matter assisted in supplying, or helped to retain, some moisture which might otherwise have been lacking.

In determining the value of plant residue of crops, grown on the land for manurial purposes, over their total removal from the land, some suggestive results were obtained. Considering the attitude of the station in strongly recommending the use of plant residues as a fertilizer these results may not be as striking as one would expect. However, it should be borne in mind that the total of such organic matter as was returned to the soil in highest quantity in these experiments amounted to only about 50 tons in the period of three years. Nevertheless, it is apparent from the results obtained on plats 15 and 17 that the increased yield, due to turning under this débris, amounted to 2 tons of fruit per acre. At the prices prevailing in 1919 this fruit would be valued at not less than $60. Perhaps the most striking lesson to be learned from this experiment is that the yield of pineapples on the land from which all the crop residues were removed had fallen to 12¾ tons, while the soil which was practically virgin produced 15¾ tons of fruit.

EXPERIMENTS IN TILLAGE PREPARATORY TO PLANTING.

Experiments were made to determine the relative value of different types of tillage with a view to bringing new soil materials to plants grown on soils that had previously been cropped and the crop residues removed. The results are shown in the following table:

Effect of dynamiting and various depths of plowing on pineapple yields.

Plat No.	Number of plants per plat.	Treatment of plats.	Average weight of fruits.	Calculated yield per acre.
			Pounds.	Tons.
1	733	Soil dynamited. One-half stick of 20 per cent dynamite was set off 30 inches below the surface on plowed land. Shots were spaced 5 by 10 feet apart, alternating	3.39	14.102
2	842	Ground subsoiled 4 inches below 12-inch plow furrows	3.41	14.185
3	643	Deep plowed without subsoiling. Furrows 12 inches deep	3.51	14.601
4	558	Shallow plowed without subsoiling. Furrows were 12 inches deep.	3.45	14.352

In these experiments the different kinds of tillage seem to have exerted little or no influence on the yields of fruit. This was probably due to the fact that all the tillage was thorough, and the 8-inch furrows were therefore adequate for the production of optimum yields. Dynamiting added fully $40 to the cost of preparing the land, and the 12-inch plowing was probably $8 per acre more than the cost of the 8-inch plowing. It is quite likely that both dynamiting and deep plowing may, under certain conditions, prove very beneficial. Dynamiting should be done in only the driest seasons; otherwise the soil may be compacted about the powder charge to a very detrimental degree. No extensive excessively deep plowing should be attempted until the nature of the subsoil or its influence on the pineapple plant is definitely known. The deep subsoil is sometimes toxic and therefore injurious to plants when it is brought to the surface.

EXPERIMENTS WITH VARIOUS TYPES OF PLANTS AND THEIR PREPARATION FOR PLANTING.

The object of experiments with various types of plants and methods of their preparation for planting was to determine their relative productivity and period of time from planting to maturing fruit; also, the effect of stripping off the basal scales or leaves preparatory to planting; planting freshly picked plants compared with seasoned plants; and the selection of superior plants compared with the general run of plants as they come from the field: (1) Planted to select slips, normal seasoning and stripping; (2) planted to select slips not stripped; (3) planted to select slips slightly stripped; (4) planted to select slips heavily stripped; (5) planted to very select slips, freshly picked, and stripped.

In determining the relative acre costs of these various practices, it was found that (1) the cost of clearing the virgin land of guava brush and stones, preparatory to using the plow, averaged $48; (2) that the cost of removing the pineapple débris was $22; and (3) that the extra cost of turning under the old pineapple plants compared with the cost of plowing the land where the débris had been removed (as in plat 2) amounted to $18. The practice of turning under old pineapple plants and hastening their decay was found to be greatly facilitated by previously breaking up the plants with a heavily weighted and well-sharpened double acting disk harrow, which was run over the fields. A furrow about 8 or 12 inches is sufficiently deep to bury the débris. The cost of growing a leguminous crop and the additional cost of turning it under was approximately $50 per acre more than the cost of plowing newly cleared virgin soil or ordinarily cropped land. The results obtained are shown in the table following.

Different methods of stripping pineapple slips and their effects.

Plat No.	Number of plants per plat.	Method of preparation.	Average weight of fruits.	Calculated yield per acre.
			Pounds.	*Tons.*
1	1,345	Basal scales or leaves of slips stripped in the customary manner	3.84	15,967
2	1,289	Basal scales or leaves of slips not stripped	3.42	14.227
3	1,359	Basal scales or leaves of slips slightly stripped	3.68	15.309
4	1,408	Basal scales or leaves heavily stripped	3.76	15.641
5	1,119	Slips; harvested and immediately stripped and planted without seasoning	4.61	19.177

The plants in plats 1, 2, 3, and 4 were seasoned for a month or two before they were stripped and planted. In these experiments all degrees of stripping the basal scales from the plants at the time of planting showed a slight advantage over the plants not stripped. Plants should be stripped, particularly in the dry season; otherwise, they are likely to become root-bound and fail to make satisfactory growth; and finally they have to be pulled up and stripped. However, during an only moderately moist season at the Haiku substation a fine lot of pineapples was grown from plants that had not been stripped. In a wet season, or in the cooler winter months, it is usually advisable to strip only slightly. Freshly harvested slips, which were lightly stripped and then planted, made most decided gains in yield of fruit over plants that were placed upside down in the open and seasoned for 30 days during July and August before planting. (See plats 4 and 5.) The difference in favor of planting the slips immediately after harvesting was an increase of approximately 3 tons of fruit, or nearly 20 per cent. In this particular, it should be borne in mind that the planting season was dry. The more moist the soil, the more thoroughly the plants should be cured.

In the experiment with different methods of culture, the flat culture (see table p. 54) generally practiced at the Patterson demonstration farm and at the Haiku substation gave slightly the best results. This method, when supplemented by subsoiling between the rows, middle busting, and cultivating the soils back into the furrows, has uniformly given the best results either in dry or wet seasons at the Haiku substation. It seems to have all the advantages of insuring good drainage (in this case the excess of water being subdrained) that the old ridging method has without having the disadvantages of erosion in heavy rains and baking in the ground in excessively dry weather. Ridging the land into beds and planting two rows on the raised bed has recently been practiced. This method has given exceptionally good results under the management of W. A. Baldwin at the Haiku Fruit & Packing Co.'s fields, especially on land that had previously failed to give satisfactory yields. In these experiments no beneficial results were obtained from ridging, either where wide or narrow, or single or double rows of pineapples were planted on the ridge. This might readily be explained in that the seasons were very dry and the soil was of good texture naturally.

It has been definitely proved that leaving the land rough, though otherwise well tilled, is best when the plants are set out in a wet season. Under such soil conditions there is much less likelihood of the soil becoming "puddled" than when it is made extremely fine. On the other hand, growers who have had good results from planting in rough ground during the past wet years have had rather disastrous results following such methods during the last two extremely dry seasons. A fine tilth seems essential to stimulate root growth in newly set plants during extremely dry seasons. The following table shows the effect of level culture compared with different forms of ridge culture:

Different methods of culture and their effects.

Plat No.	Number of plants per plat.	Method of culture.	Average weight of fruits.	Calculated yield per acre.
			Pounds.	*Tons.*
1	524	Plants set in 4-inch furrows; soil gradually drawn in so that level culture eventually prevailed. Subsoiled, middle busted, and cultivated between rows	3.38	14.061
2	1,055	Level or flat culture as practiced in the Patterson fields, unless otherwise stated. Intertilled as above	3.99	16.598
3	426	High ridge culture; single rows planted directly on ridge. Subsoiled between rows	3.36	13.977
4	731	Wide ridge culture; two rows planted to a ridge. Intertilled as above	3.32	13.811

EFFECT ON PINEAPPLES OF BURNING OVER LAND.

A question frequently asked is whether burning large quantities of brush on land that is to be planted to pineapples is likely to be detrimental to the fruit. In all the burned off areas that have been mapped out no detrimental effects were noticeable. It seems that such surface burning is not so detrimental to the soil humus as are some of the tillage practices. Large quantities of ashes when plowed into the soil may considerably alter the tilth and probably add an excess of soluble salts; in this case detrimental effects may follow, but it has rarely been the case at this station. On the other hand, there have been noted some stimulating effects from ashes but not to the extent that would be exerted on corn, potatoes, and similar crops.

METHODS OF APPLYING FERTILIZERS TO PINEAPPLES.

In recent years considerable attention has been given to the application of dried blood, reverted phosphate, hydrated and even caustic lime to the crowns of pineapples. In experiments conducted at both the Haiku substation and the Patterson demonstration farm, dried blood seemingly exerted some stimulation on recently set out and backward plants. The phosphates and lime exerted a less marked influence. However, no lasting or profitable results have thus far been obtained. The same was also true when acid phosphate, sodium nitrate, ammonium sulphate, ammonium nitrate, and Bordeaux mixture were sprayed on the surface of plants. Apparently nearly all of these preparations at times exerted a beneficial influence, even when they were applied in very weak solutions, but the effects were soon lost and no measurable results could be recorded at the final harvest. It is possible that if they were applied frequently enough, say bimonthly, more substantial results would be obtained. These experiments will be extended to another year.

While these fertilizer tests have thus far yielded comparatively small gains, some growers are doubtless obtaining adequate and profitable returns from their use. Mr. W. A. Baldwin has had fruit increased in weight fully a pound, or about 20 per cent, from the applications of ammonium sulphate as a side dressing. The immediate effect is to greatly intensify the green color of the plants. These indications of invigorated growth can usually be maintained by fractional doses applied at regular intervals up to the formation of fruit. Both the material and labor for its application are high at this time, but the practice seems justified by the high price paid for pineapples.

Inquiries are frequently received at the station asking whether pineapples will follow other crops, such as sugar cane. Some excellent pineapples have been observed to grow on old cane land under which the stubble had been turned. On the other hand, in an experiment at the Haiku substation, where all the material was removed, the young pineapple plants were looking poorly on June 30, 1920. Yet pineapples planted on a quarter of an acre from which 4-year-old eucalyptus, averaging 5 inches in diameter, were removed at the Patterson demonstration farm, are thriving and have produced an excellent first or plant crop. On a half acre from which a heavy crop of cassava had been harvested a few months previously there was growing on June 30, 1920, an excellent crop of pineapples 9 months of age.

As to natural growth as an indicator of adaptability of a soil to pineapples most guava land, which is nearly always acid and usually of a coarse, granular texture when dry, has been found suitable for pineapples. Open Hilo grasslands, which are usually also acid if the texture of the soil is at all open and coarsely granular, are usually fair pineapple lands. The lauhala and kukui lands of the Haiku region are among the best pineapple lands in dry seasons. No better test for the selection of pineapple land can be had than deep road cuts which give one a comprehensive cross section view of the soil strata below the surface. If the soil exceeds 20 inches in depth and is uniformly underlain by a loose, porous, shale-like rock, it is almost certain to produce satisfactory crops. On the other hand, if in the cross section the soil shows alternating impervious rock and subsoil ridges with deep, fine soil basins, and great variation in the soil strata, one may be sure that any resultant plantings will be spotted and give poor results, especially in a wet year. The evidence at hand indicates that the underground drainage system of any pineapple soil is one of the largest factors in the success or failure of the crop.

CORN INVESTIGATIONS.

Corn investigations, experiments, and demonstrations have continued to constitute an important work of the Haiku substation. Owing to high prices and the further stimulus caused by the urgency of producing as much of the locally consumed food as possible, the area planted to corn came to exceed 10,000 acres for the Territory. This gave corn third rank in importance among the field crops in point of area, and it has thus exchanged places with Hawaii's great food staple, rice. The latter crop, however, probably is still slightly in the lead in the total tonnage produced.

The development of the corn area has made rapid strides during the past several years and the acre yields have likewise materially increased, as was determined by an extended survey. The average production is now approximately 38 bushels (2,128 pounds), or slightly over a ton, of shelled grain per acre, which is a fair increase over 35 bushels for an earlier period. This satisfactory condition is due to several causes, the two outstanding factors being the introduction of improved varieties and strains, on the one hand (Pl. VII, figs. 1 and 2), and the extensive use of more and better suited commercial fertilizers, on the other.

Since 1914 the extension division has introduced to general culture four new and improved varieties and strains of field corn. Two of these, New Era 100-Day Yellow Dent and New Era 125-Day Yellow Dent, are of hybrid origin and were bred at the Haiku substation. The other two, S. P. I. 45903 (New Era Bantam Yellow Flint poultry corn) and Funk's Silver King, have been introduced from the mainland and have been rigidly selected for several seasons. Nearly 1,000 acres have been planted to these four varieties during the past year and they are becoming established in new corn areas, as well as replacing older varieties in other corn districts.

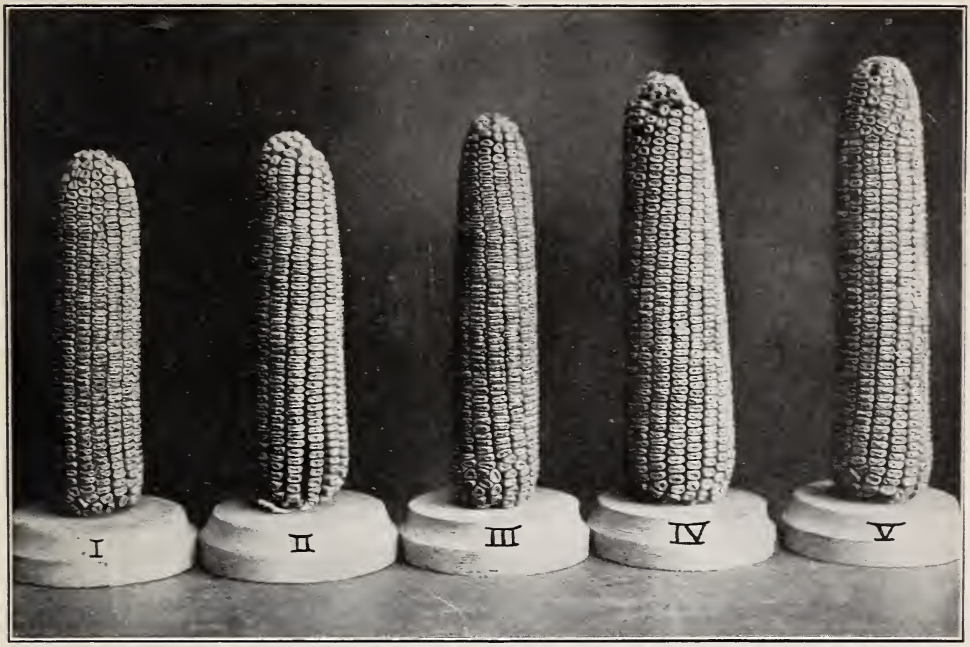

FIG. I.—VARIETIES OF YELLOW DENT CORN INTRODUCED OR DEVELOPED BY THE HAIKU SUBSTATION.

I, Bureau of Plant Industry selection No. 133; II, Funk's 90-day Yellow Dent; III, New Era 100-day Yellow Dent; IV, Reid's Yellow Dent; V, New Era 125-day Yellow Dent. Nos. III and V were developed from Funk's Yellow Dent, Reid's Yellow Dent, and Golden Leaming.

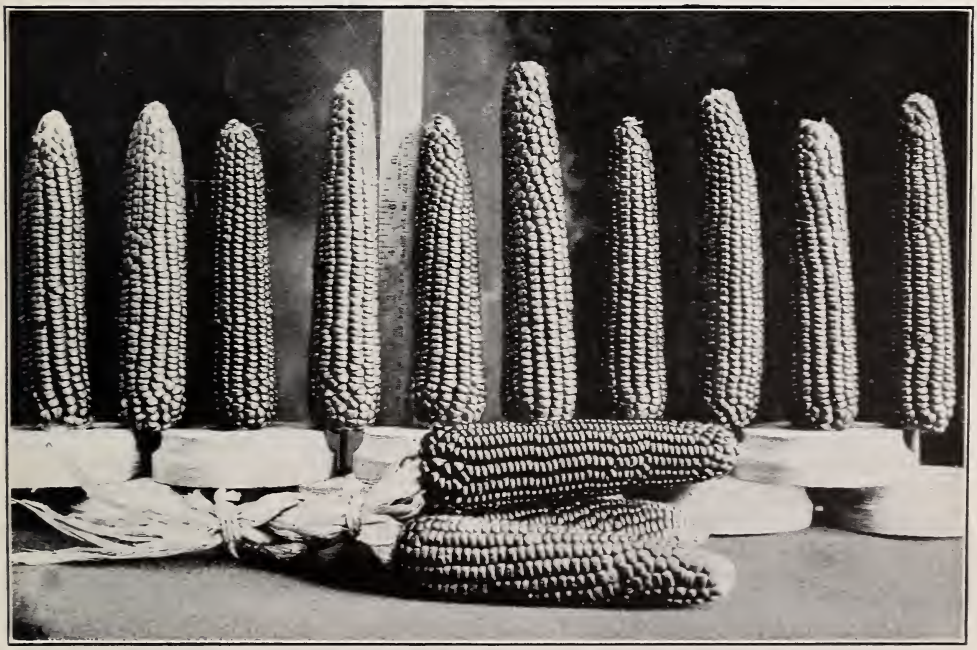

FIG. 2.—NEW ERA BANTAM YELLOW FLINT.

A variety of corn developed by the Haiku Substation. Especially valuable for poultry on account of its small grains.

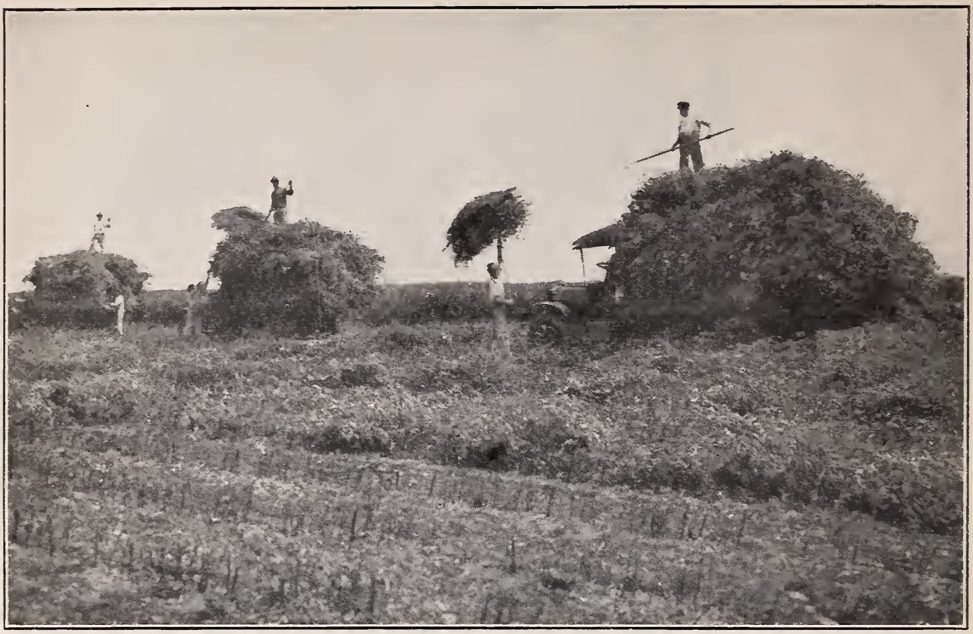

FIG. 1.—HARVESTING PIGEON-PEA HAY.

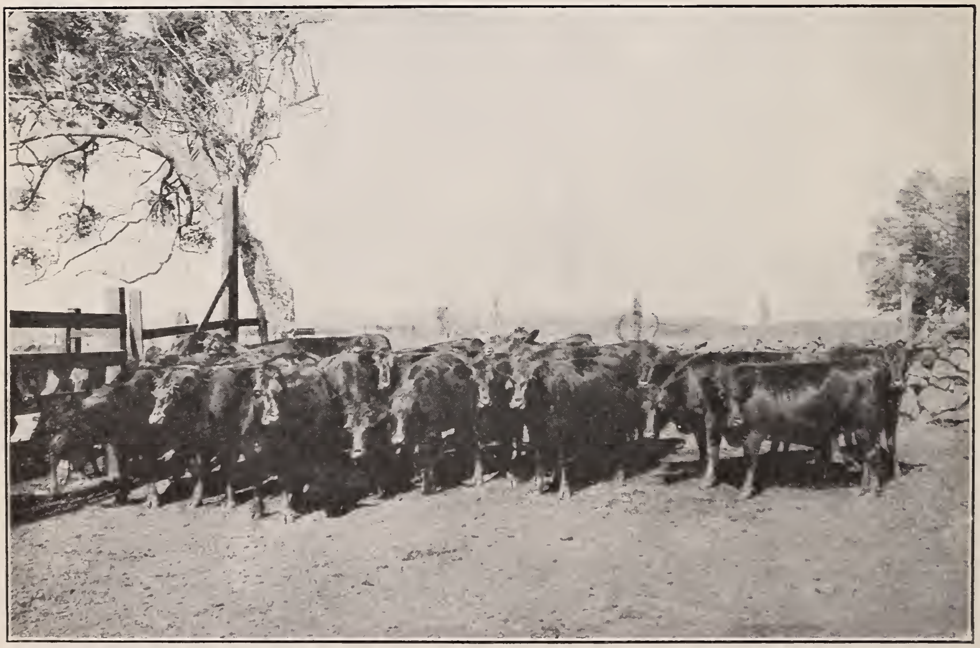

FIG. 2.—ABERDEEN-ANGUS CATTLE FATTENED ON PIGEON-PEA PASTURAGE.

The Cuban and Guam varieties, introduced by the College of Hawaii and the Hawaii Station, respectively, as well as other sorts imported by farmers, generally have also become firmly established.

During the past year there was undertaken in cooperation with the Office of Corn Investigations of the Bureau of Plant Industry, United States Department of Agriculture, studies of the effect of environment upon varieties of corn. The Bureau of Plant Industry furnished varieties, which were supplemented with local varieties such as the Kula type, an especially selected strain from the Kula district on the island of Maui.

The following table gives the results obtained in these experiments at the Haiku substation, at an altitude of 500 feet, together with the results of the fertilizer tests on the different varieties.

Results of fertilizer experiment with different varieties of corn at the Haiku substation, Haiku, Maui.

Sections and plats.	Variety.	Fertilizer used.	Number of days to appearance of silk.	Days to harvest.	Plat weight of corn shelled.	Calculated yield per acre.
					Pounds.	*Bushels.*
I......1	Kula type	No treatment	71	143	32.34	12.71
2	do	250 pounds phosphates[1]	71	143	38.50	15.13
3	do	500 pounds phosphates	71	143	42.35	16.64
4	do	750 pounds phosphates	71	143	44.66	17.55
5	do	1,000 pounds phosphates	71	143	46.20	18.15
II.....1	Mill Pond Prolific	No treatment	54	143	10.80	4.24
2	do	250 pounds phosphates[1]	54	143	11.52	4.53
3	do	500 pounds phosphates	54	143	12.96	5.09
4	do	750 pounds phosphates	54	143	14.40	5.66
5	do	1,000 pounds phosphates	54	143	16.56	6.51
III....1	S. P. I. 45903	No treatment	54	132	94.77	37.23
2	do	250 pounds phosphates[1]	54	132	103.68	40.73
3	do	500 pounds phosphates	54	132	99.63	39.14
4	do	750 pounds phosphates	54	132	101.25	39.78
5	do	1,000 pounds phosphates	54	132	97.20	38.19
IV....1	U. S. Selection 119	No treatment	69	143	69.40	26.87
2	do	250 pounds phosphates[1]	69	143	74.48	29.26
3	do	500 pounds phosphates	69	143	80.87	31.77
4	do	750 pounds phosphates	69	143	85.88	33.74
5	do	1,000 pounds phosphates	69	142	91.20	35.83
V.....1	Tuxpan	No treatment	90	[2]		
2	do	250 pounds phosphates	90	[2]		
3	do	500 pounds phosphates	90	[2]		
4	do	750 pounds phosphates	90	[2]		
5	do	1,000 pounds phosphates	90	[2]		
VI....1	U. S. Selection 133	No treatment	49	132	112.00	44.00
2	do	250 pounds phosphates[1]	49	132	131.20	51.54
3	do	500 pounds phosphates	49	132	165.60	65.06
4	do	750 pounds phosphates	49	132	156.80	61.60
5	do	1,000 pounds phosphates	49	132	184.80	72.60
VII...1	Johnson's Prolific	No treatment	59	143	35.11	13.79
2	do	250 pounds phosphates[1]	59	143	38.40	15.09
3	do	500 pounds phosphates	59	143	49.60	19.49
4	do	750 pounds phosphates	59	143	44.00	17.28
5	do	1,000 pounds phosphates	59	143	52.00	20.43
VIII..1	Funks's Silver King	No treatment	64	156	100.00	39.21
2	do	250 pounds phosphates[1]	64	156	127.20	49.97
3	do	500 pounds phosphates	64	156	174.40	68.69
4	do	750 pounds phosphates	64	156	189.60	74.49
5	do	1,000 pounds phosphates	64	156	184.80	72.60

[1] Phosphates (except where otherwise indicated) were made up of a mixture of half super (acid) phosphate and half reverted phosphate.

[2] Plants grew 10 or 12 feet tall, but failed to bear mature seed.

Results of fertilizer experiment with different varieties of corn at the Haiku substation, Haiku, Maui—Continued.

Sections and plats.	Variety.	Fertilizer used.	Number of days to appearance of silk.	Days to harvest.	Plat weight of corn shelled.	Calculated yield per acre.
					Pounds.	*Bushels.*
IX	New Era 100-Day Yellow Dent.	500 pounds phosphates[1]	52	147	[3] 184.18	71.36
X	New Era 125-Day Yellow Dent.	500 pounds phosphates[1]	62	155	[3] 198.32	77.91
XI...1	Creole (A)	No treatment	60	159	[3] 25.44	10.00
2	do	500 pounds phosphates[1]	60	161	[3] 54.40	21.37
XII...1	Creole (B)	No treatment	60	156	9.60	3.77
2	do	200 pounds bone meal	60	156	24.00	9.43
3	do	400 pounds bone meal	60	156	22.40	8.80
4	do	600 pounds bone meal	60	156	36.00	14.14
5	do	200 pounds reverted phosphate	60	156	27.20	10.69
6	do	400 pounds reverted phosphate	60	156	22.40	8.80
7	do	600 pounds reverted phosphate	60	156	36.00	14.14
8	do	200 pounds superphosphate	60	156	12.80	5.03
9	do	400 pounds superphosphate	60	156	19.20	7.54
10	do	600 pounds superphosphate	60	156	28.00	11.00
11	do	5 tons stable manure	60	156	10.40	4.09
12	do	10 tons stable manure	60	156	17.60	6.91
13	do	15 tons stable manure	60	156	19.20	7.54

[3] Although these plats were larger (as indicated in the text) the yields were calculated to the basis of plats $\frac{1}{22}$ of an acre in area in order to make the yields comparable with the yields of the other plats.

The Kula type seed was selected from local neighborhood plantings; Funk's Silver King was grown at the Haiku substation from seed originally secured from Bloomington, Ill.; New Era 100-Day Yellow Dent and 125-Day Yellow Dent were both obtained from the Haiku substation; Creole (A) was obtained from the Louisiana Agricultural Experiment Station; Creole (B) from a company in New Orleans, La.; and Johnson's Prolific through the Office of Corn Investigations, United States Department of Agriculture. The following varieties were also obtained through the Office of Corn Investigations from the places indicated: Mill Pond Prolific, Georgia; S. P. I. 45903, Argentina; U. S. Selection 119, Virginia; Tuxpan, Texas; and U. S. Selection 133, Wisconsin.

The plats in the foregoing table were planted March 21–23, 1919, and in calculating the number of days to maturity, the average date of planting, March 22, was taken as the basis. The plats planted to New Era 100-Day Yellow Dent and New Era 125-Day Yellow Dent corn were each one acre in size and the plats planted to Creole (A) were one-eighth acre each. Each of the other plats was one-twenty-second of an acre in size.

The table following gives the results obtained at Waiakoa, Kula district, island of Maui, at an altitude of approximately 3,000 feet, also under various fertilizer treatments:

Results of fertilizer experiment with different varieties of corn at Waiakoa, island of Maui.

Sections and plats.	Variety.	Fertilizer used.	Number of days to appearance of silk.	Days to harvest.	Plat weight of corn shelled.	Calculated yield per acre.
					Pounds.	*Bushels.*
A- 1	Mill Pond Prolific	Reverted phosphate	91	217	73	35.5
B- 2	.....do	No treatment (check)	91	217	82	39.8
C- 3	.....do	Superphosphate	91	217	113	54.9
A- 4	S. P. I. 45903	Reverted phosphate	61	164	47	22.8
B- 5	.....do	No treatment (check)	61	164	47	22.8
C- 6	.....do	Superphosphate	61	164	52	25.2
A- 7	U. S. Selection 119	Reverted phosphate	71	216	142	69.0
B- 8	.....do	No treatment (check)	71	216	116	56.4
C- 9	....do	Superphosphate	71	216	86	41.8
A-10	Tuxpan	Reverted phosphate	105	214	26	12.6
B-11	....do	No treatment (check)	105	214	23	11.1
C-12	.....do	Superphosphate	105	214	20	9.7
A-13	U. S. Selection 133	Reverted phosphate	57	162	49	23.8
B-14	.....do	No treatment (check)	57	162	36	17.5
C-15	.....do	Superphosphate	57	162	56	27.2
A-16	Kula type	Reverted phosphate	83	214	92	44.7
B-17	.....do	No treatment (check)	83	214	90	43.7
C-18	.....do	Superphosphate	83	214	125	60.7

Plats Nos. 1, 2, and 3 in this table were planted March 21, 1919; plats Nos. 4 to 9 were planted March 22; and the remaining plats were planted on March 24, 1919. There were 96 hills in each plat.

A third series of the experiments was undertaken at the Haleakala substation at an altitude of about 1,800 feet, but, owing to the newness of the land and the very dry season that prevailed, the results of the experiment at this point were unfortunately of doubtful value.

A study of the above tables makes clear the great variation in the productive power of different varieties of corn. The influence of climate as controlled by altitude is doubtless the principal controlling factor in this respect. Likewise is shown the marked increase in yields due to phosphatic fertilization. It is very evident from these experiments that the planting of unsuited or unadapted varieties of corn, even when heavily fertilized, may produce yields so small that their production results in a decided financial loss. In the substation experiments, Kula type, Mill Pond Prolific, the strains of the Creole variety, and Johnson's Prolific, a total of 5 out of 12 varieties, did not give returns sufficient to pay for the cost of production, regardless of treatment. Varieties S. P. I. No. 45903 and U. S. Selection No. 119 were both very early maturing and suitable for much closer planting than was practiced. These varieties produced 2,138 and 2,006 pounds of shelled corn per acre, respectively. Valued at 4 cents per pound, or $85.52 and $80.24, respectively, these two crops showed a slight profit. Both varieties might have been planted a fourth closer with a presumably corresponding increase in yield. Variety U. S. Selection No. 133, an early-maturing variety and an entirely new introduction, gave the exceptionally heavy yield of 4,065 pounds of shelled corn per acre when treated with 1,000 pounds phosphatic fertilizer; and 2,464 pounds when unfertilized. The average yields obtained from Funk's Silver King and New Era 100-Day and New Era 125-Day Yellow Dent, the local standard varieties, gave approximately the same returns as U. S. Selection No. 133; the 125-Day Yellow Dent, however, produced 4,365 pounds per acre.

In general, a substantial increase was derived from the application of the fertilizer, this increase in yield being, in most cases, fairly proportionate to the amount of phosphates applied. The lesson to be gained from these experiments is the great importance of selecting adapted varieties and of applying fertilizers where needed. Likewise, it has been shown that altitude is an important controlling environmental factor in the production of corn.

It would further seem that a very valuable new corn has been discovered for the high Kula lands in the U. S. Selection No. 119, which substantially outyielded the old standard Kula type which has been grown for 30 years. U. S. Selection No. 119, while a white-grained corn, is small seeded compared with the objectionably large seeded Kula type. The new U. S. Selection No. 119 also gives approximately 10 per cent greater shelling value than the old Kula type yielded.

POTATOES.

A new Hamakua hybrid potato, known as Yamata No. 4, was grown during the year. It is a great improvement over the original in form, color, smoothness, and culinary qualities. It also retains the resistance to blight which characterized the original variety. Tests were made of a number of varieties of potatoes, including the Hamakua hybrids. The season was one of the driest on record, and the yields were far below those of former years, less than 4 inches of rain falling during the growing period of approximately 100 days. All varieties were produced at a profit because of the high prices prevailing when the crop was harvested. At the Haleakala substation similar variety tests were conducted, and the results obtained seem to indicate that the virgin soil of that region is poorly adapted to potato growing. In all the tests the early maturing varieties invariably led in point of yield.

CASSAVA.

Considerable interest has been aroused in the growing of cassava for stock feed and other purposes, and fully 100 acres have been planted in the Haiku district. Through the cooperation of Prof.

J. F. Rock, formerly of the College of Hawaii, 10 varieties of cassava were obtained from Java. These are showing some distinct advantages over the old established varieties in a comparative test. Two varieties obtained from Florida in 1918 are continuing to give satisfactory yields. The variety Wiebke, which was received from Kauai, has proved first in quality and second in yield of all the varieties under test. During the year a feeding experiment was carried on with dairy cows and swine, which were given dried ground cassava roots, equal to about 50 tons of fresh roots. It requires 3 tons of the green roots to make one of the dried product. Ten dollars a ton was paid for fresh roots, and milling and other expenses brought the total cost of the ground product to about $40. The ground product was fed in comparison with corn at $80 a ton. When fed in equal proportions with corn, cassava meal was found equal in feeding value to corn. When fed in the fresh state 50 per cent of the ration, calculated to a dry matter basis, resulted in scours both in dairy cows and in pigs, and the milk flow of the cows was lowered by about 20 per cent. When fed to the extent of 25 and 35 per cent of this ration, calculated on a dry matter basis, fresh cassava was equivalent in feeding value to corn or wheat middlings. Although a large tonnage had been fed as fresh, sliced roots, or as pasturage, no cases of poisoning of swine have been reported in the Haiku district during the past three years.

YAMS.

Yams now grown for two seasons have shown up remarkably well under dry-weather conditions. The indigenous variety *Dioscorea sativa*, which is common in the forests of the middle altitude zones, while making comparatively slow growth, produces enormous tubers. These tubers are very palatable and apparently nutritious for hogs. The Japanese variety, *D. japonica*, develops much more rapidly, but does not yield as heavily as the *D. sativa* variety. However, it is prolific enough for profitable growing as a stock feed and has valuable culinary qualities. The Japanese prefer it to Irish or sweet potatoes. The average yield from quarter-acre plantings of the two varieties above mentioned has been approximately 18 tons per acre for the Japanese type, and 30 tons per acre for the Hawaiian type. However, the Hawaiian type has required two years for its full development compared with a year required for the Japanese variety.

SOY BEANS.

Of the many varieties of soy beans tested at the Haiku substation for forage purposes, none has ever equalled the variety Biloxi, which was obtained in Mississippi a year and a half ago by the late S. M.

Tracy, of the Bureau of Plant Industry, United States Department of Agriculture. It is heavily foliaged and at the same time it is a heavy seeder. This variety produces 20 tons of green forage per acre under favorable conditions. Unfortunately, a lot of select seed was rained upon and destroyed.

PIGEON PEAS.

No other crop with which the Hawaii Station has had experience has so quickly and fully met all the needs of a field crop as has the pigeon pea. Fully 1,000 acres are now in this crop in the Haiku district, and 1,000 additional acres are being planted at the time of this writing. Its great value as a hay crop and as a pasture crop is rapidly becoming known and there is practical evidence that under favorable conditions an acre of it will support throughout the year from one and a half to three head of mature cattle in prime condition. (Pl. VIII, figs. 1 and 2.) Three to 5 acres of native grass pasture on the same land would be required per head of cattle.

GRASSES.

Napier, or elephant grass, Merker grass, and Uba cane have competed with each other for supremacy during the past year. (Pl. II, figs. 1 and 2.) Both the Napier and Merker grasses are of much more rapid growth than is the Uba cane; and the total tonnage during the past dry season was greatest in the new plantings of Napier grass, Merker grass ranking second, and Uba cane third. However, the Uba cane, which is now three years old, when fairly started in its ratoon growth maintains its past high record very creditably. It is thought that single plantings will persist and continue to yield profitable crops much longer than either of the other two crops. About 500 acres of Uba cane is now planted in the Haiku district. This cane is among the grasses what the pigeon pea is among the legumes. The largest area of elephant grass, so far as has been observed, is that of the Hanalei ranch at Hanalei, island of Kauai. This is 20 acres in extent, and has thrived splendidly without irrigation. Under heavy irrigation and fertilization the growth has been extraordinary on the sandy beach lands at Waiamea, island of Kauai. Yields of more than 100 tons per acre per annum have been harvested. In warm, sheltered places such as Waiamea, it may be cut within 6 or 10 months from time of planting, and every 6 weeks thereafter.

REPORT OF THE EXTENSION DIVISION.

By F. G. Krauss.

This is the sixth report of the extension division and covers a period of remarkable development in the diversification of Hawaiian agriculture. The report of this division for 1915[8] made the following statement regarding diversification:

> Hawaii is peculiar in that it has no established diversified agriculture, with its usually associated groups of small independent land holdings, so familiar on the mainland. Many efforts have been made to homestead various tracts of the public lands of the Territory, but no examples of markedly successful small-farm communities are existent. The reasons have been twofold: The establishment of communities of farmers in sufficient numbers to insure their stability can not be hoped for until it has been demonstrated by actual test that a variety of crops other than the few main staples now grown can be produced economically on a commercial scale, and that, various crops having been so grown, a profitable market can be developed for their disposal.

While the development of small farming communities in the Territory has not yet attained desirable proportions, many successful individual small farms have been established since the inauguration of the extension work, and diversification of agriculture is developing in a striking and very satisfactory manner. This desirable change from the single-crop system has been brought about to a great extent by the exigencies imposed by the recent great war. Fortunately, the established agricultural interests of the Territory, such as the sugar plantations and large ranches, were quick to avail themselves of every resource at hand. The extension division's cooperation was widely sought and freely given to every agency tending to upbuild agriculture both in the practical aspects of its production and distribution and in advancing ideals for the betterment of agricultural polity. The introduction and adaptation of new field crops, the further development of the live-stock industry, and the manufacture of agricultural products typify the greater diversification. These, together with the sympathetic attitude that has been engendered toward the small independent farmer, speak well for future diversification.

Considerable progress has been made in practically all of the projects under way. During the year the work of the Patterson demonstration farm was concluded. This farm had for its purpose the practical demonstration on a field scale of the culture of crops and cropping systems that were deemed worthy of greater trial than it was possible to give them at the central experiment station and other outlying substations. It was hoped that by good farm management the homestead unit comprising the demonstration farm would be made to yield a profit where previously it had experienced serious financial loss. At the end of the 5-year period (December, 1919), under the auspices of the extension division, the farm had not only been brought under a high state of productivity through a rational system of green manuring, fertilization, and rotation, but it had fully paid the initial cost of the land and all expenditures for its development.

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[8] Hawaii Sta. Rpt. 1915, p. 45.

The Haleakala substation is situated in the midst of the newly opened homestead tract on the slopes of Haleakala.[9] It is now definitely established and the Territorial government has erected there a group of farm buildings suitable for the needs of an adequate demonstration farm project. (Pl. IX.)

At the Haiku substation culture work has been begun with new and improved field crops; a rational system of crop rotation that is most important, a workable scheme for the economical upbuilding and maintenance of soil fertility as demonstrated on the Patterson demonstration farm and by numerous collaborators, and projects for live-stock feeding and dairying are partly under way. A small experimental dairy has already been built and stocked with purebred and high-grade dairy cattle. The piggeries have been enlarged and improved. A small experimental cassava starch mill is under construction as an outcome of investigations conducted on the mainland a year ago.

The extension division took an active part in the Maui County Agricultural Fair and in fostering the development of the boys' and girls' pig clubs, which have proved a marked success. The policy was continued of assisting the farmers in the Territory and of rendering useful services to Hawaii. Possibly never before were its services more in demand than during the past year. Frequent visits of the superintendent to the other islands were necessitated through urgent requests from many who desired a thorough investigation of their problems and practical advice concerning the best methods of solution.

During the year just closed a weekly agricultural page in one of the leading daily papers was edited in cooperation with the director of the central experiment station. Numerous popular articles on agricultural subjects were also prepared for various publications, and frequent lectures were given to large audiences. A bulletin, entitled "The Pigeon Pea (*Cajanus indicus* or *C. cajan*): Its Culture and Utilization in Hawaii," was prepared and submitted for publication during the year. It is thought this will be an important contribution to the agricultural interests of the Territory, and it is hoped that the pigeon pea will revolutionize the live-stock industry of the islands.

Every year the demand increases for seeds of new varieties and improved strains. Of the pigeon pea alone, more than 5 tons of selected extension division grown stocks, sufficient to plant over 1,000 acres, have been distributed during the past three years. Most of the

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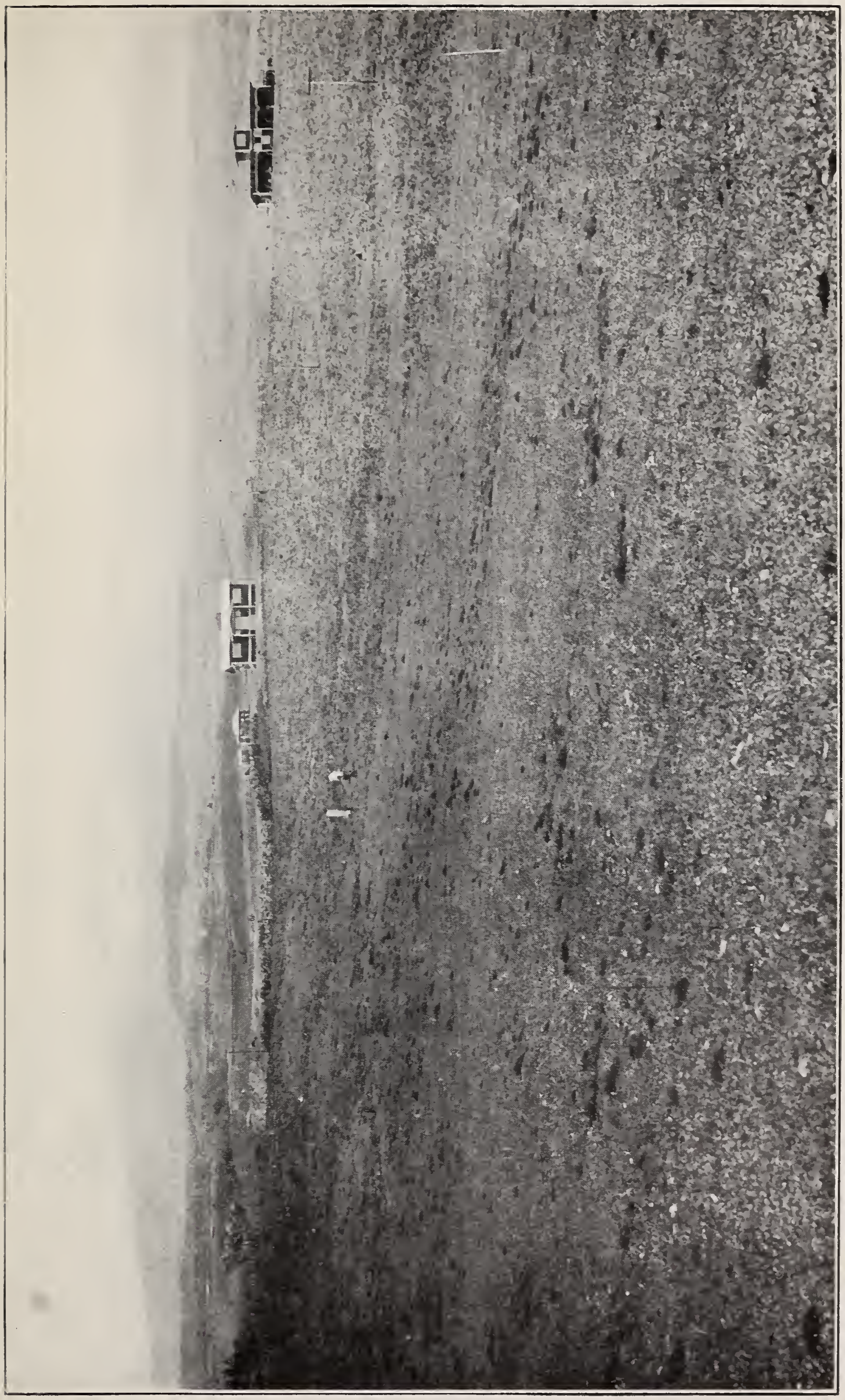
[9] Hawaii Sta. Rpt. 1919, p. 58.

PLATE IX.



HALEAKALA DEMONSTRATION FARM, SHOWING BUILDINGS RECENTLY ERECTED BY THE TERRITORIAL GOVERNMENT.

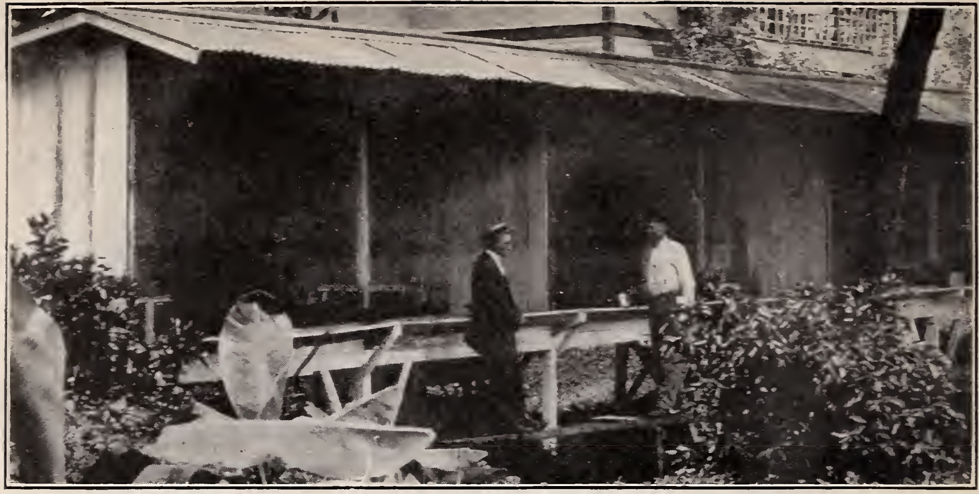


FIG I.—OPEN FRONT POULTRY HOUSES, RAISED FROM GROUND.

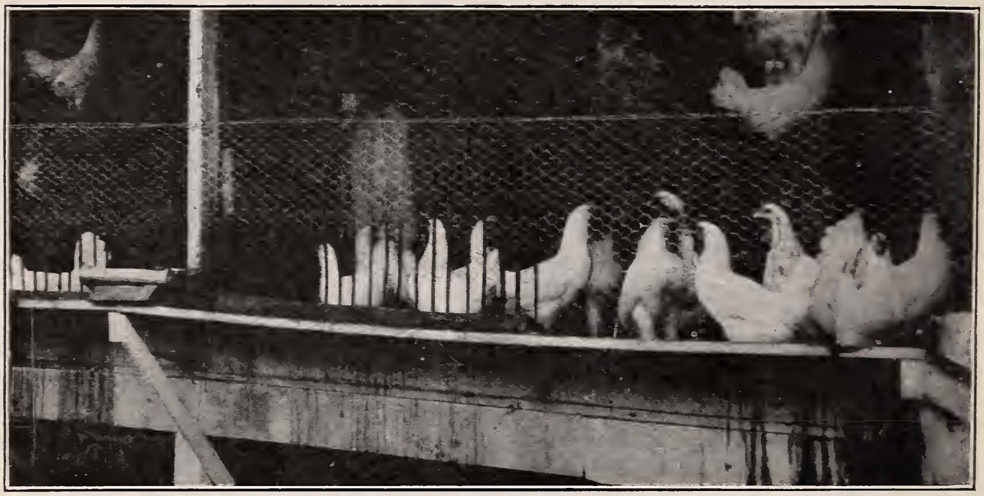


FIG. 2.—OPEN FRONT HOUSES, HENS WITHOUT ACCESS TO GROUND.

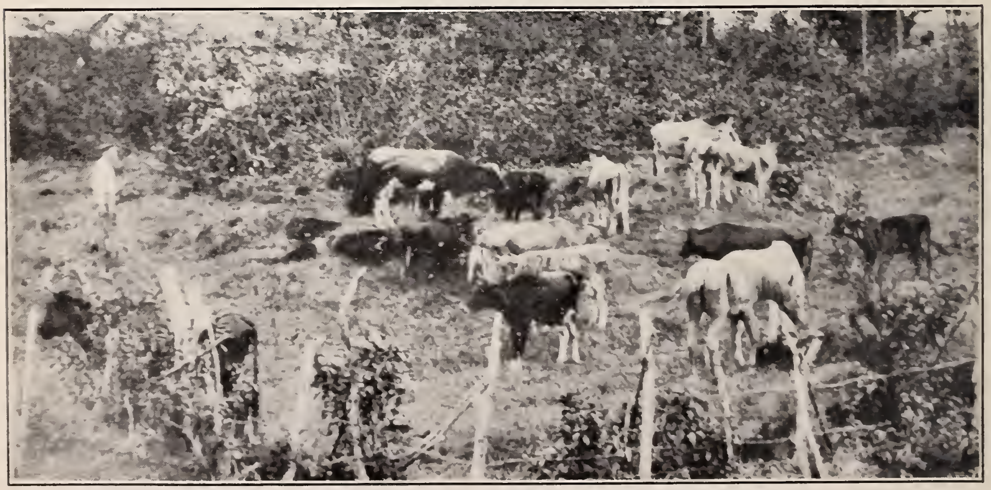


FIG. 3.—DAIRY COWS ON PASPALUM PASTURE.

COOPERATIVE POULTRY AND DAIRY WORK IN HAWAII.

strains which were developed by the demonstration farm are now fully established and widely distributed. For this reason and on account of the labor and expense involved in their propagation by the station, the future production and dissemination will depend upon private concerns and individuals. This has created a new and important industry, that of growing tropical farm seeds, and will probably result in increased wealth and a better agriculture for Hawaii.

Experiments with swine and poultry will result in the production of surplus stock, the choicest of which will be given the widest distribution possible.

COLLABORATORS.

The work of the collaborators of the extension division continues to be a most important feature for disseminating practical farm information and for testing various crops and methods of tillage under the direction of the division. It is hoped that a greater number of collaborators can be employed during the coming year because they keep the division in close touch with the activities of the various agricultural districts of the islands.

The work of John de C. Jerves, collaborator at Kalaheo, Kauai, is a very important factor in the agricultural development not only of his own immediate district but of all the islands. Thousands of cuttings of his now well-known "Madeira" sweet potato were shipped during the year. He has gone rather heavily into the breeding of pure Berkshire swine, and is doing much to encourage the small farmers in his vicinity to replace the poorer types with pure breeds.

In like manner the work of J. E. Gamalielson, one of the collaborators at Kaumana, Hawaii, advances the cause of diversified agriculture in the islands. His activities cover a wide field. Especially noteworthy are those in the marketing of dairy and poultry products (Pl. X, figs. 1, 2, and 3) and in the establishment, largely under his guidance, of a cooperative store under the Rochdale system. His report for his business year from January 1 to December 31, 1919, is as follows:

> During the year 4,776 pounds of butter were marketed for the farmers who, collectively, are known as the Glenwood Creamery Co. The price paid per pound was a little over 67½ cents. The total returns amounted to $3,228.11. A nominal charge of 4 cents per pound was made for selling the butter. This was $169.06 for the year or about 5½ per cent. Most of the butter came from farmers in the upper part of the Olaa district near Mountain View and Glenwood, and consisted of that which was left after the local demand was supplied. For this reason the supply was somewhat irregular. The smallest lots generally arrived when there was a shortage of imported butter, and the largest shipments came when the local market was well filled with imported butter.

Such irregularity is a distinct disadvantage because orders for future delivery can never be taken with any certainty of filling them, and an oversupply often meets a well-filled market in Honolulu or elsewhere. The largest quantity received at any time during the year was 79 pounds, and the smallest quantity was 24 pounds. Mondays and Thursdays of each week are set aside for marketing, and about two extra days each month for billing, collection, and settling up. This year a total of 127 days, or parts of days, were used for this work.

Much of the writer's time has been devoted to the organization of a cooperative market for farm produce. With the cooperation of X. L. Helbush, H. E. Kelsey, and others, this organization was incorporated December, 1919, under the name of the Rochdale Cooperative Association (Ltd.), of Hilo. It started with a capitalization of $25,000, but this amount had to be doubled in a short time to take care of the stock subscriptions which came in. The membership roll now contains 440 names. About $28,000 worth of stock has been subscribed and probably $17,000 paid in. The business of the store has practically doubled since its start, and the sales for May amounted to $9,255.62. They would have been higher had the store been equipped to handle more. The house, which is a rented one, has already been outgrown. It is planned to build a suitable structure on a centrally located site, where it is the intention to handle island-produced eggs, butter, meats, fruits, vegetables, and all kinds of home produce, in addition to general merchandise.

Some experiments in feeding bananas to milk cows have been carried on at the writer's own farm at Kaumana, and the results are rather promising. The milk yield of one cow was increased 2 pounds the morning following the feeding of 10 bananas as the evening ration. This increase continued for several days, returning at the rate of 1 cent for each banana eaten. The number of bananas was then doubled, but proved too much. The cow refused them the next meal and came down in milk yield. After a couple of days she again took the bananas, and was being fed about a dozen nearly ripe bananas at a time when the supply gave out. During this time she returned in milk from 0.75 to 1 cent for each banana. Two other cows were experimented with and showed practically the same results. As the supply of bananas was so limited it was impossible to carry on the experiment to where any definite conclusions could be reached; however, the writer has compared the composition and general characteristics of bananas with other concentrates and can see no reason why bananas should not prove satisfactory in every way. Some feeds tried have been found to be negative in results for the first few days, but they prove satisfactory after the cows get used to them. Other feeds have a stimulating effect at first, causing a large flow of milk the first few days only. Bananas may, of course, belong to this latter class of feeds. However, the writer considers bananas the most promising crop he has ever tried as feed for live stock in Hawaii. Sweet potatoes are good, but bananas are the surer crop of the two. They can be grown at a much higher elevation, are much cheaper to produce, and are always clean, requiring no washing as sweet potatoes do. They seem to give best results if sliced when firm and a little bran or middlings is sprinkled on them to absorb the juice. Care must be taken not to overfeed the cattle, especially at first.

The theory of the survival of the fittest still holds good as regards chickens. When the writer started to raise chickens here some 10 years ago it was possible to raise to maturity only from 10 to 20 per cent of the chickens hatched. Sorehead was such a pest that the young chickens when about a month old would drop off like flies. After trying all kinds of remedies for two years it was discovered that some of the most vigorous chickens could not be infected. It was then decided to raise as many of the vigorous kind as possible. Several hundred of the affected chickens were killed and a careful study was made to learn how the stronger ones became so robust, so that subsequent hatches might be properly cared for. All hatches have been carefully watched ever since and now only those chickens that have been accidentally weakened beforehand get affected. No drugs or serums of any kind are used, nor are they required. The same characteristics that make for immunity against disease naturally also tend to promote egg production. The pullets begin laying at about 5 months of age, and continue well through the molting season the first year. The second year they fall off about two-thirds in egg production during the molting season.

The liver fluke has been a very serious pest among the cattle for the last couple of years. Three cows and two big steers died from the effects of it on this farm last year, and a number of cows were so much affected that they aborted and yielded no milk. Starting on the theory that the myna birds would take care of the snails harboring the pest if given a chance, it was decided to burn all grass that was rank enough to hide the snails. As a result, no new cases have developed during the last 7 or 8 months. The animals are now in good condition and are functioning normally; and it is thought that burning over the pasture is proving effective.

The following is a financial report of my farm for the 5 months' period ending May 31, 1920:

Records of operations and business transactions on the Gamalielson farm.

EXPENDITURES.	
Feed for chickens and cows	$755.45
Hired help on the farm	473.90
Electric light, heat, power	54.05
Telephone rent	20.20
Land rent	50.00
Taxes and licenses (apportioned)	119.30
Repairs to motor cars and machinery	52.90
Gasoline and lubricating oils	41.30
House repairs	23.85
Fences and repairs to same	25.10
Interest and insurance apportioned for five months	25.40
Allowance for depreciation and death of hens	300.00
Total expenses for period	1,941.45

RECEIPTS.	
Eggs marketed (dozen), 2,383½	$2,148.08
Butter marketed (pounds), 721½	520.76
Cream marketed (quarts), 80	78.60
Chickens marketed (No.), 176	161.92
Vegetables marketed	8.00
Accrued incoming rent on farm land	211.00
Value of chickens raised	500.00
One hide sold	6.20
Miscellaneous items	173.92
Total income for period	3,808.48
Total expenses for period	1,941.45
Gain during period	1,867.03
Monthly income for five months	373.40
Interest on capital invested	125.00
Labor income per month	248.40

EXTENSION WORK ON THE ISLAND OF HAWAII.

The work of R. A. Goff, extension agent, on the island of Hawaii, is especially noteworthy. This large territory is regularly gone over by Mr. Goff, who has succeeded in stimulating the small farmers to renewed efforts in developing their various projects. Some of the large plantations frequently call upon Mr. Goff for practical advice along diversified lines of agriculture, and his office has acted as a very efficient intermediary between the farmer, rancher, and planter, and the central experiment station. Mr. Goff's report immediately follows.

REPORT OF THE EXTENSION AGENT ON THE ISLAND OF HAWAII.

By R. A. Goff.

The extension agent for the island of Hawaii visited and assisted as much as possible all those who were interested in any form of diversified agriculture. Problems were discussed with the individual farmer, talks were given at meetings, literature and seed were distributed, and, along educational lines, a course of study on agricultural subjects was outlined for use in the graded schools in cooperation with the vocational director of the public schools on this island.

DISTRIBUTION OF SEED.

Potato, corn, alfalfa, clover, edible canna, cassava, elephant grass, and poha seed were distributed to farmers and plantation managers in each district of the island. This planting material is from varieties which have been grown at the Glenwood substation or in other localities at lower elevations where it was found adapted to local weather and soil conditions. Seed or seedlings of fruit trees such as avocado, mango, papaya, Macadamia nut, limes, lemon, and orange were also given to those who wanted them. Seedlings of varieties of fruit trees requiring grafting or budding when they were sufficiently matured were given this treatment.

DISTRIBUTION OF LITERATURE.

Sixty United States Department of Agriculture and Hawaii Experiment Station bulletins, over 300 agricultural pages of an island newspaper edited by F. G. Krauss, of the extension division, and 16 Yearbooks of the Department of Agriculture were given to the farmers during the year.

DEMONSTRATION PLATS.

Alfalfa and elephant grass have been planted for trial on homesteads, plantations, and in school gardens in the Kau, Olaa, Hilo, and Hamakua districts. Only two of the plantations have extended their plantings enough to produce part of the feed consumed by plantation animals because of the frequent cultivations required to hold the perennial grasses in check. These crops are finding great favor with homesteaders who need an area of an acre or less to supply feed for a small number of cows, hogs, and poultry.

FARMERS' MEETINGS.

On the east side of the island of Hawaii homestead associations are taking an active interest in projects in which the members can cooperate. These associations were formed primarily for the purpose of cooperating in the production and marketing of sugar cane, but practically all the members are interested in some kind of diversified agriculture. The extension agent has given talks at these meetings when questions were raised concerning soil improvement, securing seed and fruit trees, markets for surplus produce, or animal raising.

MARKETING LOCAL CROPS.

Potato growers in the Glenwood and Waimea districts have had difficulty in finding a market for their crops during the harvesting seasons, which occurs in May, June, October, and November. This trouble was due to the fact that the wholesale houses order their potatoes from California throughout the greater part of the year. Dealers know what their average sales will be, and have standing orders with coast firms for their supply. As the island crops approached maturity the extension agent made an estimate of their yields. These data were given to the merchants so that they could cancel their orders with California firms during the months when the home-grown potatoes would supply the market.

Hawaii generally has an oversupply of bananas throughout the year, and an effort is being made to secure continuous and reliable transportation for this product in California, where they bring $4.90 per hundredweight wholesale. Indications are that the price will remain this high for a number of years. The varieties in demand are the Bluefield and the Chinese, which are easily grown anywhere on the island up to an altitude of 1,200 feet. Transportation has been the only difficulty encountered in disposing of bananas. For the past seven months trial shipments have been made on the steamer *Enterprise*, which sails to the coast direct, and on the larger Matson boats, which go by way of Honolulu. Transportation difficulties probably have now been overcome, only one shipment arriving in San Francisco in damaged condition, and this being due to careless wrapping. At the time the bananas are delivered in Hilo, $3 is paid per hundredweight at the wharf, and the commission merchant assumes all risk while the fruit is on board ship. This has given the growers confidence and they are planting small areas to bananas in fields that are not suitable for growing sugar cane. The extension agent notifies the growers by telephone when a steamer arrives; he also advises them of the time of the steamer's departure and of the fruit inspector's visit. The growers are met on the wharf and paid on the day the steamer leaves, and the necessary papers dealing with the shipment of the fruit are drawn up. The shipments have gradually increased in size. This would seem to show that the growers are satisfied with the arrangement made for transporting and selling the fruit. No one will be urged to increase the size of his banana fields until the shipments have proved entirely successful and there is no question regarding the permanency of the demand.

BOY SCOUT EXAMINATIONS.

The extension agent has acted as examiner for all boy scouts who competed for the agricultural merit badge. Classes, attended by both high school and graded school boys, were held to assist those preparing for the examination. Weeds and insect pests were identified and the methods of eradication were discussed. Budding and grafting were demonstrated. Samples of soil were collected from different localities on the east side of the island, and the needs and methods of improvement of each were shown. Three kinds of seed testers were made and used. The useful and harmful birds of the locality were identified. Trips were made to nearby plantations and homesteads to inspect and learn the uses of plows, cultivators, harrows, and disks.

SCHOOL AND HOME GARDEN CONTESTS.

The school and home gardens of 14 school districts in the Hamakua, North Hilo, and South Hilo districts were visited and prizes were awarded. Official trips with two other judges were made by the extension agent, one in March and another in June. During the time of the contest, from the first of January to the middle of June, the extension agent visited these gardens and conducted spraying demonstrations, gave talks to the garden boys, and distributed seed.

BOYS' WORKING RESERVE.

In 1919 both boys and girls were enrolled in the Reserve in nearly all the schools of the island. Talks were given the school children, and, with the cooperation of men having moving-picture machines, exhibitions were given, showing what was being done on the mainland to increase food production. Badges were distributed, usually at morning assembly of the entire school, to those who had worked during the summer.

EDUCATIONAL WORK IN CROP PRODUCTION.

A large percentage of the children of oriental parentage in the island do not attend school after their fourteenth year. In cooperation with Mr. F. A. Clowes, vocational instructor of Hawaii, a course has been outlined which will give these children an elementary idea of vegetable growing, sugar-cane production, animal raising, and work about the house. These courses are being expanded into short lessons for school use. Each week a certain number of hours are devoted to this work so that the pupil will have an opportunity to learn by actually doing the work outlined in his lessons.

The great need of this work was shown by the school-garden contest, which was conducted by a Honolulu newspaper. This paper has been doing some excellent pioneer work in vocational training in agriculture in the public schools of the islands, and the contests should be continued. Studies of field crops and animal raising should also be introduced as part of the school work.

GLENWOOD DEMONSTRATION FARM.

All Territorial financial support of the Glenwood substation was withdrawn on July 1, 1919, to establish another experiment station in the Waimea district on the opposite side of the island. The equipment of the Glenwood substation was temporarily made available for helping to maintain this substation as a self-supporting demonstration farm under a collaborator who receives general direction from the extension agent. The former superintendent of the Glenwood substation was made extension agent for the island of Hawaii. However, he has been able to give some attention to the general oversight of the demonstration farm, which replaced the Glenwood substation. A large part of the experimental work with crops was curtailed and attention was concentrated on those crops which had proved well adapted to Glenwood conditions. Small, well-established plats of alfalfa were kept up and fed fresh to the animals. Corn, alfalfa, and stock carrots were planted and the yields, which were slightly less than those of the previous year, were fed either to the poultry or to the hogs. Edible canna and cassava were harvested and new plantings were made. Both the roots and tops of the edible canna were fed to hogs, and for three months formed a large part of their ration. The cassava was "hogged down" by the animals which were turned into the field and allowed to harvest the roots for themselves. Plantings of Hamakua Hybrid potatoes were made and seed was distributed to homesteaders, and the culls were fed to the hogs.

A number of hogs were purchased by the farm to increase its returns and to consume its crops. Six purebred Berkshires and 25 hogs of mongrel blood were secured. The Berkshires were fed alfalfa which had been wilted for 12 hours, elephant grass, edible canna tops and roots, and skimmed milk and middlings. With the exception of one animal, which developed a cough after being accidentally exposed to rain, all of the purebred hogs are doing well and give promise of making good breeding stock. The scrub hogs, which had been secured locally, were largely brought in from the forest and were in a semiwild state. They were fed hapu, the heart of the tree fern, which was practically their only feed when they were in the forest. To this were added chopped green alfalfa, skimmed milk, and corn meal. After experimenting with them for two months it was found that nothing could be gained by feeding them and they were sold. As a result of this trial the farm sustained a loss in money, but it demonstrated the superiority of well-bred hogs over common stock.

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